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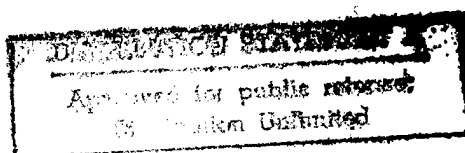
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No. 29



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14

13 October 1983

USSR REPORT  
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## CONTENTS

## METEOROLOGY

|  |    |
|--|----|
| Cosmic Horizons in Climatology<br>(Kirill Yakovlevich Kondray'yev; PRIRODA, Apr 83).....   | 1  |
| Investigating Spectral Transparency of Crystalline<br>Cloud Medium<br>(O. A. Volkovitskiy, et al.; IZVESTIYA AKADEMII<br>NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, May 83).....  | 16 |
| Modeling Influence of Stratospheric Temperature Changes<br>on Growth of Sulfate Aerosol Droplets<br>(D. I. Busygina, A. S. Kabanov; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I<br>OKEANA, May 83).....                    | 17 |
| Global Model of Ocean-Atmosphere System and<br>Investigation of Its Response to Change in CO <sub>2</sub><br>Concentration<br>(V. V. Aleksandrov, et al.; IZVESTIYA AKADEMII<br>NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, May 83)..... | 17 |
| Numerical Model of Tropical Cyclone With Computation<br>of Condensation at Grid-Resolved Scales<br>(A. P. Khain; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....  | 18 |
| Long-Period Atmospheric Oscillations<br>(G. M. Teptin; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, Apr 83).....  | 19 |
| Method for Computing Natural Components of<br>Meteorological Fields<br>(N. M. Datsenko, et al.; IZVESTIYA AKADEMII NAUK<br>SSSR: FIZIKA ATMOSFERY I OKEANA, Apr 83).....   | 19 |

|   |    |
|---|----|
| Refining Radiation Model of Stratiform Cloud<br>(B. A. Kargin, V. S. Troynikov; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I<br>OKEANA, Apr 83).....   | 20 |
| Possible Nature of Prethunderstorm Electromagnetic<br>Emission of Convective Clouds<br>(I. M. Imyanitov, V. N. Morozov; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I<br>OKEANA, Apr 83).....   | 21 |
| Exchange of Oxygen and Carbon Dioxide Between Arctic<br>Ocean and Atmosphere<br>(Yu. I. Lyakhin, V. P. Rusanov; DOKLADY AKADEMII<br>NAUK SSSR, Jul 83).....   | 21 |
| Determination and Prediction of Northern Hemisphere<br>Temperatures Based on Fluctuations in Tree Growth<br>Indices at the Polar Tree Line<br>(B. L. Berri, et al.; VESTNIK MOSKOVSKOGO<br>UNIVERSITETA, SERIYA 5: GEOGRAFIYA, Jul-Aug 83)..... | 22 |
| OCEANOGRAPHY  |    |
| Improved Tsunami Warning Service in Maritime Kray<br>(L. Stukun; VODNYY TRANSPORT, 25 Jun 83).....  | 23 |
| Cruises of Fisheries Research Ship 'Akademik Knipovich'<br>(D. Ye. Gershanovich, T. G. Lyubimova;<br>RYBNOYE KHOZYAYSTVO, Jul 83).....  | 25 |
| New Research Ship to Explore for Manganese Nodules<br>(RADYANS'KA UKRAYINA, 9 Aug 83).....  | 29 |
| Convective Cooling of Fluid From Free Surface<br>(A. A. Grachev; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....   | 30 |
| Method for Computing Swell Resonance Frontal Waves<br>(G. V. Matushevskiy; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....   | 30 |
| Attenuation of Ocean Surface Wave Caused by Radiation<br>of Waves Into Atmosphere<br>(V. I. Pavlov, Yu. Slabeytsius; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA,<br>May 83).....  | 31 |
| Parameters of Lomonosov Current Meandering<br>(V. A. Bubnov; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....   | 32 |

|   |    |
|---|----|
| Characteristics of Restricted Light Beam in Absorbing<br>Medium With Narrow Scattering Function<br>(L. S. Dolin; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, Apr 83).....   | 32 |
| Effect of Bottom Relief on Stability of Two-Layer<br>Jet Flow<br>(A. A. Abramov, et al.; IZVESTIYA AKADEMII<br>NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, Apr 83).....   | 33 |
| Construction of the Crust of the Shatskiy and Hess<br>Submarine Elevations (Pacific Ocean) Based on Seismic<br>Survey-Reflected Wave Method Data<br>(L. I. Kogan, et al.; BYULLETEN'MOSKOVSKOGO<br>OBSHCHESTVA ISPYTATELEY PRIRODY: OTDEL<br>GEOLOGICHESKIY, Jul-Aug 83)..... | 34 |
| One Pecularity of Generation of Rossby Waves in<br>Stratified Ocean<br>(G. M. Resnik; OKEANOLOGIYA, May-Jun 83).....  | 34 |
| Synoptic Numerical Prediction of Currents in<br>Polymode Area<br>(D. G. Seidov; OKEANOLOGIYA, May-Jun 83).....  | 35 |
| Experiments on Modeling of Self-Oscillations Resulting<br>From Interaction of Ocean and Atmosphere<br>(L. V. Daricheva, V. I. Chuprynin;<br>OKEANOLOGIYA, May-Jun 83).....  | 35 |
| Equatorial Currents in Pacific Ocean at Meridian 180°<br>(V. A. Bubnov, V. D. Yegorikhin;<br>OKEANOLOGIYA, May-Jun 83).....   | 36 |
| Diagnostic Calculations of Water Circulation in the<br>Australia-New Zealand Sector of Antarctic Ocean Based<br>on Poley-South-81 Expedition<br>(V. N. Malek; OKEANOLOGIYA, May-Jun 83).....  | 37 |
| Medium Scale-Vortices in Ocean and Their Geographic<br>Propagation<br>(A. S. Blatov, et al.; VESTNIK MOSKOVSKOGO<br>UNIVERSITETA, SERIYA 5: GEOGRAFIYA, Jul-Aug 83).....  | 37 |

#### TERRESTRIAL GEOPHYSICS

|  |    |
|--|----|
| Two Types of Quiet in Seismoacoustic Prediction<br>(A. A. Berdyayev, V. A. Mukhamedov; DOKLADY<br>AKADEMII NAUK SSSR, May 83)..... | 39 |
|--|----|

|   |    |
|---|----|
| Geomagnetic Field Changes Associated With Seismic Activity in Tashkent Geodynamic Polygon<br>(G. A. Mavlyanov, et al.; DOKLADY AKADEMII NAUK SSSR, May 83).....   | 40 |
| Interrelationship of Earthquake Magnitude and Thermodynamic Parameters in Focal Region<br>(L. I. Tuliani; DOKLADY AKADEMII NAUK SSSR, May 83).....  | 41 |
| Some Results of Continuous Two-Frequency Seismoacoustic Profiling<br>(V. A. Vasil'kov, et al.; IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA, May 83).....   | 42 |
| Generation of Electromagnetic Radiation Upon Oscillation of Double Electric Layers and Its Manifestation in Earthquakes<br>(M. Ye. Perel'man, N. G. Khatiashvili, DOKLADY AKADEMII NAUK SSSR, Jul 83).....  | 42 |
| Specifics of Time Course of Radon Content in Subsoil Atmosphere in Seismically Active Zones of Western Fergana Before Earthquakes of 18 October and 11 December 1980<br>(A. K. Abduvaliyev, A. K., et al.; DOKLADY AKADEMII NAUK SSSR, Jul 83)..... | 43 |
| Effectiveness of Seismic Methods in the Search for Nonanticlinal Oil and Gas Traps in Southeast of Northern Sakhalin<br>(M. G. Bulatov, I. K. Tuyezov; TIKHOOKEANSKAYA GEOLOGIYA, May-Jun 83).....  | 43 |
| Change in Seismic Velocities in Northern Sakhalin<br>(S. A. Ballod; TIKHOOKEANSKAYA GEOLOGIYA, May-Jun 83).....   | 44 |
| Geoelectric Cross Section of Southern Primor'ye Based on Magnetotelluric Soundings<br>(S. S. Starzhinskiy; TIKHOOKEANSKAYA GEOLOGIYA, May-Jun 83).....  | 45 |
| Bottom Structure of Northwestern Portion of Sea of Okhotsk<br>(A. A. Andreyev, et al.; TIKHOOKEANSKAYA GEOLOGIYA, May-Jun 83).....  | 45 |
| Acoustical Precursors and Fracture Kinetics<br>(V. A. Mukhamedov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, May 83).....  | 46 |

|  |    |
|--|----|
| Comparative Description of Groundwater Flow and Level<br>Reaction Before Earthquakes<br>(F. I. Monakhov, et al.; IZVESTIYA AKADEMII<br>NAUK SSSR: FIZIKA ZEMLI, May 83).....                                 | 46 |
| Modeling and Predicting of Fracture by Percolation<br>Theory<br>(T. L. Zhelidze; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ZEMLI, May 83).....   | 47 |
| Density Heterogeneities in the Mantle Based on Data on<br>Depth to Its Free Surface. Continental Regions<br>(M. Ye. Artem'ev, et al.; IZVESTIYA AKADEMII<br>NAUK SSSR: FIZIKA ZEMLI, May 83).....            | 48 |
| Solution of Direct Gravimetry and Magnetometry Problems<br>in Relation to Modeling of Complex Geological Media<br>(G. G. Rempel'; GEOLOGIYA I GEOFIZIKA, Jun 83).....  | 48 |
| General Features of Pacific Ocean Bed Geodynamics<br>(B. Kh. Yegiazarov, E. M. Litvinov; GEOLOGIYA<br>I GEOFIZIKA, Jan 83).....  | 49 |
| Oil and Gas Geological Regionalization and Prospects<br>for Oil and Gas Content of Ukraine<br>(P. F. Shpak; GEOLOGICHESKIY ZHURNAL, Jul-Aug 83).....   | 49 |
| Characteristics Relating Oil and Gas Content of Crust<br>With Surface Shape of Geoid and Geomagnetic Field<br>(Ye. S. Shtengelov; GEOLOGICHESKIY ZHURNAL,<br>Jul-Aug 83).....                                | 50 |
| Optimal Linear Phase Correcting Filtration as Means for<br>Increasing Resolution of Seismic Record<br>(Yu. K. Tyapkin, G. G. Nauko; GEOFIZICHESKIY<br>ZHURNAL, Jul-Aug 83).....                              | 50 |
| Results of Scaling of Anomalys Magnetic Field Into<br>Lower Half-Space on Southern Margin of West Siberian Platform<br>(T. L. Zakharova, L. A. Sharlovskaya; GEOLOGIYA I<br>GEOFIZIKA, Apr 83).....          | 51 |
| Earth Core Model and Geomagnetic Field<br>(V. V. Kuznetsov; GEOLOGIYA I GEOFIZIKA, May 83).....  | 52 |
| Calculation of Earth Surface Deformations Based on<br>Gravitational Data<br>(L. A. Maslov; GEOLOGIYA I GEOFIZIKA, May 83).....   | 52 |
| Structural-Genetic Analysis for Interpretation of<br>Potential Geophysical Fields From the Systems Approach<br>(M. M. Semenduyev; VESTNIK MOSKOVSKOGO UNIVERSITETA,<br>SERIYA 4: GEOLOGIYA, May-Jun 83)..... | 53 |



|  |    |
|--|----|
| Study of Shear Fracture Formation and Seismic Conditions<br>in Samples Containing Low Strength Inclusions<br>(F. Rummel, G. A. Sobolev; IZVESTIYA AKADEMII<br>NAUK SSSR: FIZIKA ZEMLI, Jun 83).....  | 53 |
| Steady Corrections for Longitudinal, Transverse and<br>Surface Waves in Uniform Magnitude System of Eurasian<br>Continent<br>(I. Vanek, et al.; IZVESTIYA AKADEMII NAUK<br>SSSR: FIZIKA ZEMLI, Jun 83).....  | 54 |
| Study of Underground Water Conditions for Determination<br>of Hydrogeodynamic Earthquake Precursors<br>(I. G. Kissin, et al.; IZVESTIYA AKADEMII NAUK<br>SSSR: FIZIKA ZEMLI, Jun 83).....  | 55 |
| PHYSICS OF ATMOSPHERE  |    |
| Transport of Admixtures by Eddy Currents and Stochastic<br>Reduction of Meteorological Fields<br>(Ye. A. Novikov; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....   | 57 |
| Momentum Transport by Eddy Perturbations With Loss of<br>Stability of Plane Axially Symmetric Shear Current<br>(V. A. Dovzhenko, V. A. Krymov; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I<br>OKEANA, May 83).....   | 58 |
| Oscillatory Spectrum of Water Dimers<br>(A. A. Vigasin; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....   | 58 |
| Combination Scattering Laser Spectrometer<br>(Yu. S. Georgiyevskiy, V. M. Kopeykin;<br>IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY<br>I OKEANA, May 83).....  | 59 |
| Dynamics of Localized Vortical Perturbations--<br>'Vortex Charges' in Baroclinic Fluid<br>(V. M. Gryanik; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....   | 60 |
| Radiative Dissipation of Temperature Perturbations in<br>Earth's Upper Atmosphere With Allowance for Disruption<br>of Local Thermodynamic Equilibrium<br>(G. M. Shved, D. P. Utyakovskiy; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, May 83)..... | 60 |
| Polarization Contrast<br>(G. V. Rozenberg; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, May 83).....  | 61 |

|  |    |
|--|----|
| Shortened Description of Cloudless Sky Brightness Spectra<br>(N. A. Stavitskaya, A. A. Yakovlev; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA,<br>May 83).....   | 62 |
| Remote Determination of Atmospheric Temperature by Lidar<br>From Rotational Spectrum of Combination Scattering<br>(Yu. F. Arshinov, S. M. Bobrovnikov; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA,<br>Apr 83).....                       | 62 |
| Matrix Coefficient of Radiation Brightness Reflected by<br>Semi-Infinite Absorbing Medium With Highly Anisotropic<br>Scattering Function<br>(E. P. Zege, L. I. Chaykovskaya; IZVESTIYA<br>AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA,<br>Apr 83)..... | 63 |
| Model Computations of Turbulent Diffusion Coefficients<br>for Nonstratified Atmospheric Surface Layer<br>(V. M. Tsarenko; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, Apr 83).....   | 64 |
| Spatial Problem of Flow of Incompressible Stratified<br>Fluid Around Obstacle (Numerical Modeling)<br>(I. G. Granberg; IZVESTIYA AKADEMII NAUK SSSR:<br>FIZIKA ATMOSFERY I OKEANA, Apr 83).....  | 64 |
| Influence of Perturbations in Lower Ionosphere<br>Parameters by Powerful, Radio Waves on Partially<br>Reflected Signals<br>(S. I. Martynenko, L. F. Chernogor;<br>GEOFIZICHESKIY ZHURNAL, Jul-Aug 83).....   | 65 |

## METEOROLOGY

### COSMIC HORIZONS IN CLIMATOLOGY

Moscow PRIRODA in Russian No 4, Apr 83 pp 23-33

[Article by Kirill Yakovlevich Kondrat'yev]

[Text] Kirill Yakovlevich Kondrat'yev is a corresponding member of the USSR Academy of Sciences and chief of the Remote Methods Laboratory of the USSR Academy of Sciences' Institute of Limnology. He is a specialist in the field of physics of the atmosphere and space studies of the atmosphere, as well as the author of a number of scientific and popular science works on these questions, including the following books: "Radiation Factors in Contemporary Global Changes in Climate," Leningrad, 1980; "The Worldwide Climatic Research Program: Status, Prospects and the Role of Observation Facilities in Space," Moscow, 1982.

What will the climate be like after 10, 20 and 100 years? Specialists in different countries throughout the world are trying to answer this question, which is one of concern for every inhabitant of our planet. However, it must be said that in contemporary science there exist different viewpoints on this subject. For instance, the World Meteorological Organization's statement on the change in climate reads: "Further cooling is most probable," because since 1940 the average annual temperature on Earth has decreased by 0.5°C. If this tendency toward a drop in temperature is maintained for 200-300 years, a new Ice Age can appear on Earth. True, later on in the statement there is a stipulation: "The total effect of anthropogenic factors should result in a warming effect"<sup>1</sup>. At the same time there exists another opinion, as expressed by the well-known Soviet climatologist M.I. Budyko, that there can possibly be a catastrophic rise in temperature by the year 2000, caused by an increase in discharges of heat and carbon dioxide by modern industry. This prediction was made on the basis of theoretical estimates and an analysis of the trend toward an increase in temperature in certain regions of the Earth that was observed in the 1970's.

The coexistence of different opinions about future changes in climate can be explained briefly by a quote from the same statement: "The present understanding of the causes of fluctuations in climate is only rudimentary." The theory of climate

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<sup>1</sup>World Meteorological Organization Executive Committee, 28th session. Document No 33, Appendix B, June 1976, pp 3-4.

Table 1. Possible Factors in Change in Climate by the Year 2000

| Source of origin of factor | Factor  | Probability of significant change | Probability of substantial effect of change in factor on climate | Main climatic effect                                   | Characteristic time of climatic changes |
|----------------------------|---|-----------------------------------|--|--|---|
| Solar                      | Change in solar constant  | Low                               | High   | Warming-cooling  | Months and more                         |
|                            | Variations in solar radiation   | High                              | Low to moderate  | Unclear  | Days and more                           |
| Lunar-                     | Tidal disturbances  | High                              | Moderate   | Changes in cloudiness and precipitation (1-10 percent) | Days, weeks and more                    |
| Volcanic                   | Discharges of aerosol into the atmosphere                                       | High                              | Moderate to high   | Cooling (0.1-1°C)                                      | Years and more                          |
|                            | Increase in amount of carbon dioxide in the atmosphere                          | High                              | Moderate to high   | Warming (1°C)  | Century                                 |
| Anthropogenic              | Increase in amount of dust in the atmosphere                                    | Moderate                          | Low to moderate  | Warming-cooling  | Days and more                           |
|                            | Increase in amount of freon in the atmosphere                                   | Moderate*                         | Moderate   | Warming  | Decade and more                         |
|                            | Decrease in ozone content caused by nitrogen oxides, freon and other substances | Moderate*                         | Moderate   | Increase in ultraviolet radiation                      | Years and more                          |
|                            | Thermal pollution   | High                              | High (local effects)   | (10 percent) Warming, local clouds and storms          | Recent decades                          |
| Oceans                     | Changes in underlying surface caused by land utilization                        | Moderate                          | Moderate (regional effects)                                      | Changes in temperature and precipitation               | Months and more                         |
|                            | Change in ocean surface's temperature   | High                              | Moderate to high (regional effects)                              | Changes in temperature and precipitation               | Months and more                         |

Table 1 (continued)

|                 |  |          |                             |   |                 |
|-----------------|--|----------|-----------------------------|---|-----------------|
| Cryo-<br>sphere | Variability of polar ice                 | Low      | High                        | Rise in sea level, possible glaciation  | Years and more  |
|                 | Variations in area of ice and snow cover | High     | Moderate (regional effects) | Change in temperature and precipitation | Months and more |
| Biosphere       | Change in plant cover                    | Moderate | Moderate (regional effects) | Change in temperature and precipitation | Years and       |

\*Assuming restrictions on the production of freon since 1980.

is extraordinarily complicated because of the diversity of the natural factors that determine it. The superimposition of so-called anthropogenic factors on them makes prediction an even more complicated problem.

It is a well-known fact that the atmosphere's properties are caused by the most variegated terrestrial and nonterrestrial factors: long-period internal fluctuations in the atmosphere-ocean-continent-cryosphere system, variations in the solar constant, the Sun's ultraviolet radiation, tides arising under the influence of the Sun and the Moon, displacement of the continents and the drift of the poles, discharges of various substances into the atmosphere and so on.

We attempted to define the possible factors in changes in the climate by the year 2000 and obtained a rather extensive table, although far from everything has been taken into consideration in it. A discussion of the study of the effect of each of these factors on climate would occupy a great deal of space, so we will dwell on only a few processes, in the investigation of which results have been achieved that make it possible to hope for a successful solution of the problem of prediction.

#### Active-Energy Zones in the Ocean

One of these processes is the interaction of the atmosphere with the ocean, which is a gigantic reservoir of heat. The exchange of heat, moisture and momentum between the atmosphere and the ocean determines to a considerable degree long-term anomalies in weather and climate.

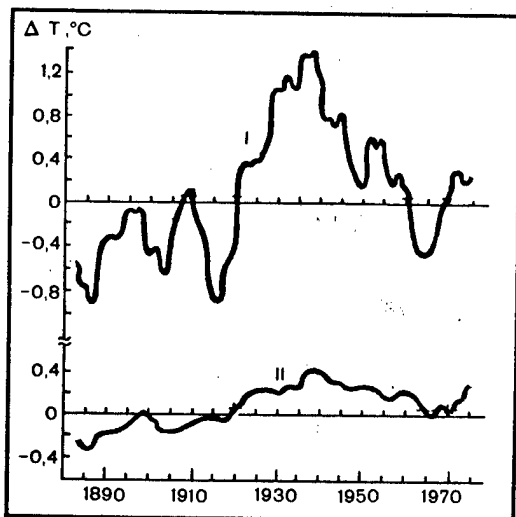
With the help of the so-called apparatus of conjugate equations of thermodynamics and a special form of the theory of disturbances that has been constructed, G.I. Marchuk and his associates succeeded in establishing that temperature anomalies are determined to a significant degree by processes occurring in different regions of the world ocean where a huge amount of heat passes into the atmosphere. These regions were given the name "active-energy zones in the ocean"<sup>1</sup>.

The existence of these zones was confirmed by global maps of the world ocean's thermal balance (compiled from observational data) and previously determined empirical relationships between the state of the ocean and the subsequent weather.

For instance, the analysis of data on the world ocean's thermal balance showed, for example, that in January in the Northern Hemisphere the maximum values of the heat flows from the ocean into the atmosphere are seen in the western part of the Sargasso Sea, to the east of Newfoundland, in the Norwegian Sea and to the east of Japan. Although the area of the Newfoundland and Norwegian zones of maximum heat transfer is only about 25 percent of the area of the North Atlantic, their contribution to the total flow of heat from the ocean's surface into the atmosphere reaches 47 percent above 40° North Latitude. In the Southern Hemisphere in July, the zones of maximum heat transfer are located in the area of Drake Passage, to the south of Africa, in the area of the Tasman Sea and from 60° South Latitude south to Antarctica. Active-energy zones are characterized by the highest degree of variability of the ocean's surface temperature. Many of them are coupled with warm currents

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<sup>1</sup>Kondrat'yev, K.Ya., "The World Ocean and Long-Term Weather Prediction," in "Chelovek i stikhiya" [Man and the Elements], Leningrad, 1981, p 29.



Secular pattern of changes in air temperature in the Northern Hemisphere. Based on the tendencies toward an increase in temperature observed in the 1970's, a prediction was made of global warming of the climate by the year 2000: I. 72.5-87.5° North Latitude belt; II. 17.5-87.5° North Latitude belt.

ice, as well as the areas of formation of powerful monsoon currents in the Indian Ocean and other regions of the world ocean.

From the viewpoint of their contribution to the formation of long-term weather anomalies, the role of the different zones changes significantly in the course of a year and from year to year. The discovery of active-energy zones makes it possible to hope for considerable success in the solution of the problem of long-term climatic prediction. By concentrating the actually available resources for normal observations (primarily ships) on the tracking of the development of processes in the active-energy zones (it goes without saying that their variability and migration should be taken into consideration) and using observational data from satellites, it may be possible to achieve a more thorough understanding of the phenomena that control long-term weather anomalies and climatic changes.

Work has already begun in some of these regions under the Soviet national program "Razrezy" [Profiles], the main purpose of which is investigations of short-term (from a month to several years) changes in climate that are manifested as anomalies in several meteorological parameters (primarily temperature) over large areas of the Earth. The component parts of the "Razrezy" program, which is based on the concept of active-energy zones in the ocean, are both full-scale investigations in different key climatic regions and numerical experiments utilizing the observational data that have been obtained.

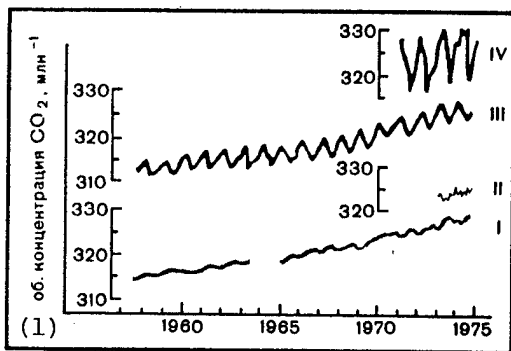
#### Monitoring Climate From Satellites

Investigations from artificial Earth satellites, which make it possible to conduct a global review of the Earth's atmosphere, ocean, plant cover and so on, have acquired

flowing from the lower to the higher latitudes. These currents include the Gulf Stream and its continuation in the North Atlantic, as well as the Kuroshio Current and its continuation in the Pacific Ocean.

The presence of an active-energy zone in Drake Passage is caused by the interaction of the Antarctic Circumpolar Current, which engirdles Antarctica, with the Peruvian and Brazilian Currents. The active-energy zone located to the south of Africa is related to the Agulhas Current, whereas the one in the Tasman Sea is related to the East Australian Current.

Of special interest is the tropical belt of the world ocean, which absorbs a gigantic amount of solar radiation, part of which is then transferred to the higher latitudes. According to observational data, in the 10-30° South Latitude belt the amount of heat given off by the upper layer of the ocean reaches 350 W/m<sup>2</sup>. The active-energy zones also include the migration zones of the edges of the polar



Change in carbon dioxide concentration, based on observational data from different points on Earth: I. South Pole; II. Samoan Islands; III. Mauna Loa (Hawaii); IV. Point Barrow (Alaska).

Key: 1. Volumetric concentration of  $\text{CO}_2$ , ppm

how much energy different regions of the globe receive from the Sun and how much is emitted into space in the form of thermal radiation. As it turned out, information about the Earth's energy balance that was obtained on the basis of terrestrial observations was inaccurate. On the average the Earth is darker and warmer, as we have learned with the help of satellites. "Darker" refers to the Earth's reflectivity, or albedo, which is several percent lower than it was previously thought to be, whereas "warmer" means that emissions from the Earth, as determined by the planet's apparent temperature, are more intensive, since the apparent temperature is higher by several degrees. These facts are of primary importance for explaining the process of climate formation and changes in it.

Satellite meteorology has shown that remote sensing of the atmosphere from space is a very promising field. Previously our primary source of information about temperature, pressure and moisture was so-called aerological sensing. We launched balloons carrying sensors that made it possible to make direct measurements at altitudes up to 40 km. In the last 10-15 years, however, it has been demonstrated that analogous (not only not direct, but indirect) measurements can also be made from satellites. The fact of the matter is that if thermal emissions are measured on different wavelengths, it is possible to more or less "stratify" the atmosphere and recover its vertical temperature and moisture profiles.

We have been very successful in determining wind direction and velocity at different altitudes by tracking the movements of clouds in (temporally) sequential pictures of cloud cover that are obtained with the help of geostationary satellites (those that are injected into orbit over the equator at an altitude of about 37,000 km and have an orbital period of 24 hours, so that they "hang" over a certain point on the Earth's surface).

A worldwide meteorological experiment was carried out in 1979. The preparations for it took 10 years and it made it possible, for the first time, to obtain quite complete meteorological information for the entire globe for a period of 1 year. The experiment was based on the use of both standard and space observational facilities.

a special role in the study of the Earth's climate and the development of long-term predictions for it.

Meteorological Earth satellites have been in existence for almost 20 years. With their help we have obtained rather extensive information about the regularities of the distribution of cloud cover on this planet. We have learned to determine the quantity and shapes of clouds, measure the temperature and altitude of their upper boundaries, and differentiate their phase status; that is, to judge whether they contain water or ice.

Satellites have produced very important information about the energetics of different regions of the globe and the Earth as a whole. It has been used to determine





Wind velocity vector fields at levels of upper and lower clouds stages, as determined from data obtained by tracking cloud cover dynamics from the ATS-3 geostationary satellite. Wind velocity at levels:  $\bullet \rightarrow$  = upper level clouds;  $\circ \rightarrow$  = lower level clouds.

The space "sector" included five satellites in geostationary and four in polar (that is, passing over the poles) orbits, which provided a daily, worldwide review of the weather. In connection with this, an important role was played by direct measurements of atmospheric pressure, air temperature, wind velocity and other meteorological parameters made by sounding balloons floating in the atmosphere and buoys drifting in the ocean, which information was then transmitted via satellites to data reception and processing systems on the ground. The materials obtained during the experiment are now being used to test theoretical models of the overall circulation in the atmosphere<sup>1</sup>.

#### The Atmosphere's Greenhouse Effect

One of the most popular hypotheses about changes in climate, both in the geological past and at the present time, couples variations in temperature with changes in the atmosphere's carbon dioxide content that give rise to changes in the greenhouse effect. That is the name given to the atmosphere's property of letting solar radiation pass through but holding back terrestrial emissions, thereby contributing to accumulations of the Earth's heat. Only in the so-called transparency windows does the emission of heat take place without hindrance. The most important transparency

<sup>1</sup>Kurbatkin, G.P., "Hydrodynamic Models of Climate," PRIRODA, No 9, 1981.

Table 2. Dependence of Increase in Temperature of Earth's Surface on Increase in CO<sub>2</sub> Concentration by a Factor of N\*

| N            | 1 | 1,5 | 2   | 3   | 4   | 5    | 6    | 7    | 8    | 10   |
|--------------|---|-----|-----|-----|-----|------|------|------|------|------|
| $\Delta T'$  | 0 | 1,6 | 2,4 | 4,1 | 5,1 | 5,7  | 6,3  | 6,7  | 7,2  | 8,1  |
| $\Delta T''$ | 0 | 2,9 | 4,4 | 7,6 | 9,4 | 10,4 | 11,2 | 11,2 | 12,5 | 13,1 |

\*The values of  $\Delta T'$  and  $\Delta T''$  correspond to values of increase in temperature obtained with and without allowing for the atmosphere's moisture content.

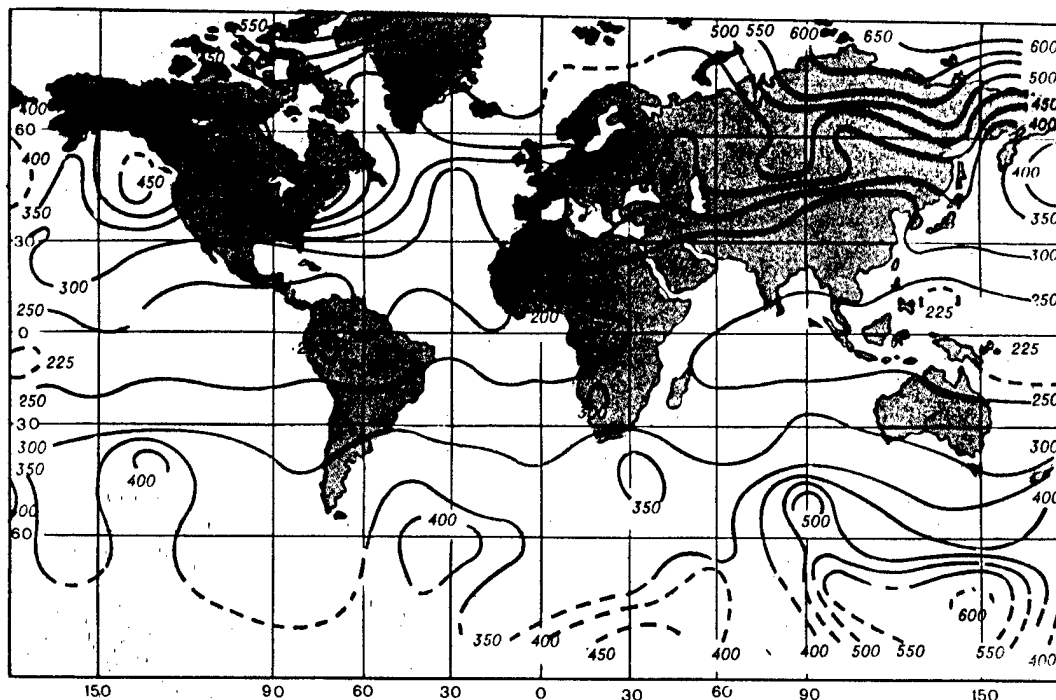
window is in the 7-14  $\mu\text{m}$  band of wavelengths. The main contribution to the formation of the greenhouse effect is made by the water vapor and carbon dioxide contained in the atmosphere. When the carbon dioxide content increases, therefore, the greenhouse effect intensifies.

It is known, however, that the atmosphere's absorption spectrum in the transparency windows in the 7-14  $\mu\text{m}$  wavelength band is determined not only by the effect of carbon dioxide, but also by such gaseous components as ozone and many others, as well as aerosols. From the viewpoint of the theory of climatic change, the most important role naturally belongs to those optically active components for which long-term variability is typical. In connection with this, a special place is occupied by fluorochloromethanes (freon), which are components of the atmosphere that have an exclusively anthropogenic origin. The scale of the discharge of freon into the atmosphere is increasing constantly.

For the purpose of studying the effect of gaseous and aerosol components on the greenhouse effect, the author of this article and N.I. Moskalenko calculated the radiation flows for models of the Earth's atmosphere with different chemical compositions. The theoretical model included many components that have an effect on the absorption of radiation in the Earth's atmosphere: water vapor, carbon dioxide, nitrogen and oxygen, methane, nitrogen oxide, nitrous oxide, nitrogen dioxide, sulfur dioxide, nitric acid vapors, ethylene, acetylene, ethane, formaldehyde, fluorochloromethanes (freon), ammonia, aerosol formations with different chemical compositions and microstructures (particle sizes) and others.

Table 2 shows the theoretical dependence of an increase in the Earth's surface temperature on an increase in the CO<sub>2</sub> concentration, both allowing and not allowing for feedback from the atmosphere's moisture content (which increases as the climate warms up). What calls attention to itself is that the indirect effect of CO<sub>2</sub> on the change in temperature of this planet's surface (through its effect on the atmosphere's moisture content) is equivalent to an increase in the greenhouse effect because of variations in the absorption of radiation by CO<sub>2</sub>. It is a characteristic feature that cloud cover is a stabilizing factor in the establishment of climate on Earth, since it limits the increase in temperature because of the action of the greenhouse effect of optically active gaseous components. As the amount of moisture in the atmosphere increases, so does the degree of coverage of the sky by cloud cover, which reduces the amount of solar radiation accumulated by the planet surface-atmosphere system.

Calculations of the possible warming on Earth because of an increase in the CO<sub>2</sub> concentration showed that this effect is expressed most strongly in the cold polar regions, for which a doubling of the CO<sub>2</sub> concentration can result in warming of the surface by 5°C.



Distribution of total content of ozone in the atmosphere (in Dobson units) according to data from measurements made by the "Nimbus-3" satellite on successive orbits during the course of a day.

Doubling the nitrogen concentration results in an increase in the average temperature of  $0.7^{\circ}\text{C}$ , whereas doubling of the ammonium and methane concentrations causes it to increase by  $0.1$  and  $0.3^{\circ}\text{C}$ , respectively. A 20-fold increase in the freon content can result in a greenhouse effect on the order of  $0.6$ – $1^{\circ}\text{C}$ , and the total greenhouse effect from the doubling of the concentrations of  $\text{N}_2\text{O}$ ,  $\text{CH}_4$ ,  $\text{SO}_2$  and  $\text{HNO}_3$  reaches  $1.2^{\circ}\text{C}$ .

In greenhouse effect calculations it is important to allow for such gaseous components as  $\text{CCl}_4$  and  $\text{CF}_4$ , which have strong absorption bands near  $10\ \mu\text{m}$ . An increase in the industrial discharges of  $\text{CCl}_4$  and  $\text{CF}_4$  in the future can lead to intensification of the greenhouse effect by  $0.8$ – $1^{\circ}\text{C}$ .

The stratosphere is colder than the troposphere, and the greenhouse effect manifests itself there more noticeably. For instance, doubling the amount of water vapor in the stratosphere results in warming by  $1^{\circ}\text{C}$ , whereas a 25-percent reduction in the amount of ozone because of destruction of the ozone layer causes cooling to the extent of  $0.4$ – $0.5^{\circ}\text{C}$ . Thus, allowing for a significant number of small components, the effect of which on the climate was previously thought to be negligibly small, indicates a trend toward possible warming of the climate caused by the anthropogenic output of small gaseous components. Therefore, the need for tracking global changes in their concentrations cannot be doubted.

When discussing the possible variations in climate as the result of an anthropogenic change in the atmosphere's chemical composition, it is necessary to take into consideration the interrelationships between different climate-forming factors. For example, an increase in the chlorofluoromethane [sic] content can change the

atmospheric ozone content substantially. In connection with this, it is important that the change in the ozone content is very irregular as far as altitude is concerned. Calculations have shown that the greenhouse effect caused by ozone is very sensitive to variations in its vertical structure and is manifested not only through the direct effect of ozone, but also indirectly, through other atmospheric components that vary as a result of a change in the vertical temperature profile in the stratosphere. Although a uniform reduction in the ozone concentration by 25 percent leads to a reduction in the surface's temperature of  $0.45^{\circ}\text{C}$  for a planetary-average model of the atmosphere, irregular reduction of the ozone concentration causes an antigreenhouse effect:  $-0.25^{\circ}\text{C}$ . It is important to consider variations in ozone not only in the stratosphere but also in the troposphere, since variations in tropospheric ozone frequently result in inverse effects in comparison with the results caused by stratospheric changes in the ozone concentration.

The complex nature of the greenhouse effect indicates the necessity of watching the different small gaseous components of the atmosphere that are optically active. Different techniques are now being developed and used for this purpose. They are based on the principle that the content of small gaseous components in the atmosphere can be determined just as the atmosphere's temperature at different levels can: by satellite measurements of the atmosphere's thermal radiation on different wavelengths.

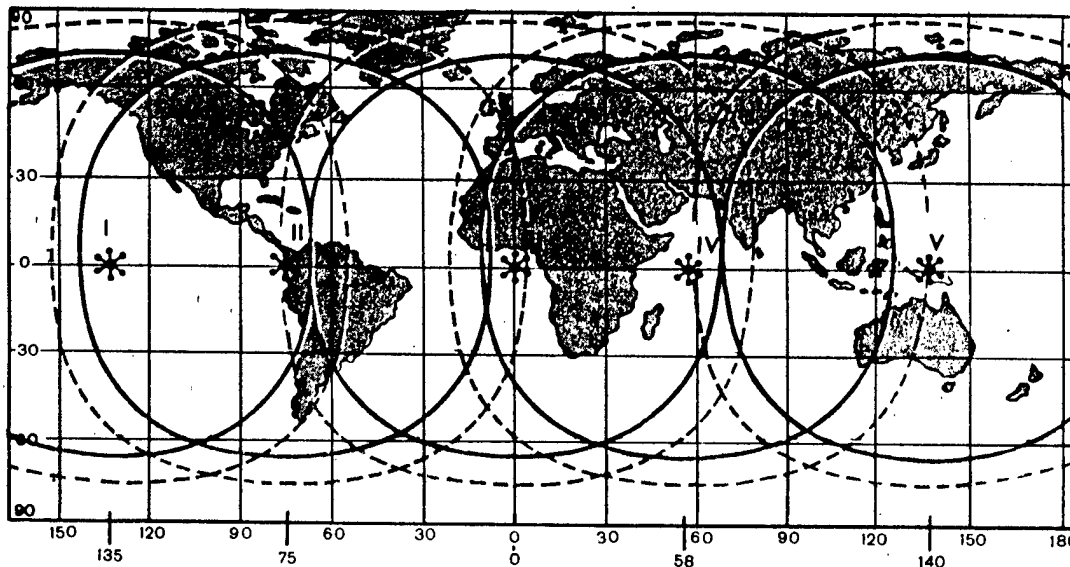
There also exists a much more efficient possibility: installing equipment in a satellite that can measure the attenuation of solar radiation on its path through the atmosphere from the Sun to the satellite as the Sun rises and sets with respect to the satellite and conducting experiments with a so-called eclipse configuration. Such an experiment for the determination of the composition of the atmosphere's small components was first conducted on the "Salyut-4" manned orbital station, which carried a complex of solar spectrometers that made it possible to register solar radiation on different wavelengths as the Sun rose and set relative to the orbital station, when the solar rays were passing through the atmosphere layer. By measuring the absorption of solar rays by the atmosphere layer it is possible to obtain, for example, information about the content of water vapor and ozone in the atmosphere.

#### Investigations by Cosmonauts

We now know that orbital stations are a very effective means for testing various equipment. A clear example of this is the testing on the "Salyut-6" orbital station of a radiotelescope, which is a complicated device with a large antenna. It would have been difficult to test it on an automatic satellite (the episode of Cosmonaut V.V. Ryumin's walk in open space comes to mind).

We should add here that the visual observations made by cosmonauts also play a very large role. A cosmonaut observing the Earth from space is also capable of evaluating a favorable or unfavorable situation for conducting planned experiments and is of significant assistance in improving the effectiveness of experiments. This is indicated in the reports of cosmonauts from the "Salyut-7" orbital station.

Thus, by using different approaches it is possible to realize--and this was partially done in the past--different methods for determining the content of small components in the atmosphere. However, we also know that a substantial effect on the



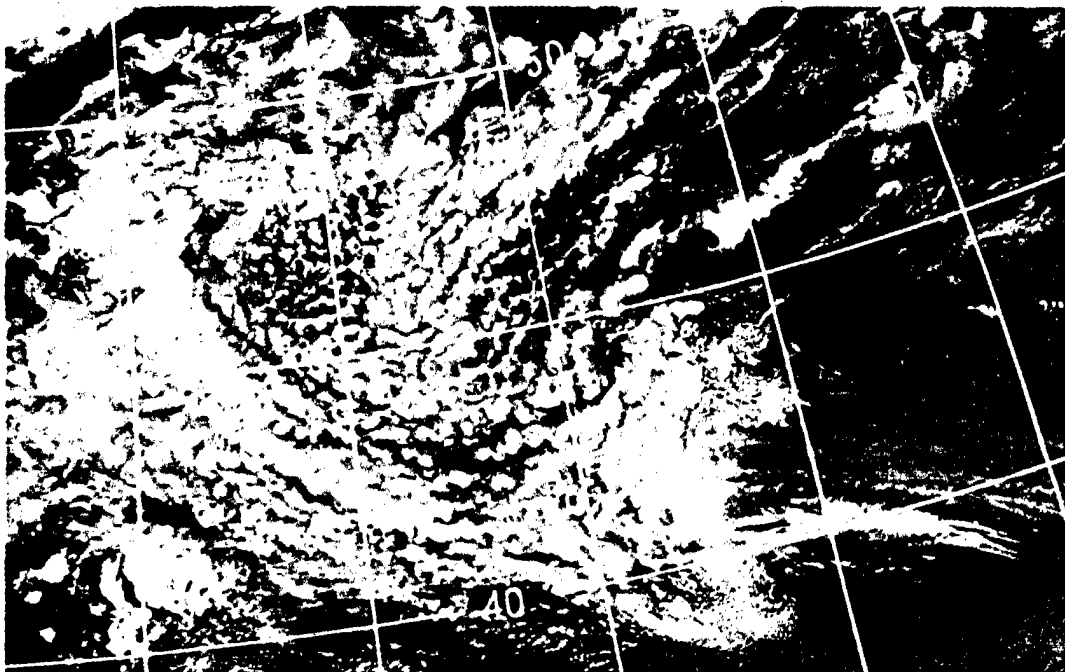
Plan of observations with the help of five geostationary satellites during the worldwide meteorological experiment (1979): I, II, IV = American geostationary satellites for environmental observations; III = geostationary satellite of the European Space Agency; V = ("Khimavari") Japanese geostationary meteorological satellite. The solid lines delineate the zone of constant observations; the dotted lines--intermittent observations.

atmosphere's properties--and, in the final account, on climate--can be exerted by atmospheric dust (atmospheric aerosols) of different origin, particularly those that appear after large volcanic eruptions.

An analysis of pictures of Earth taken from space showed that large dust clouds appearing, shall we say, in a region of deserts are quite clearly visible in photographs. True, they make it possible to determine only the area of propagation of dust and to see exactly where a dust cloud appeared in a desert and what territory it encompassed. However, we are interested in evaluating the amount of dust in the atmosphere and determining the change in dust concentration with altitude. This requires observations with instruments.

The experience gained in working in the manned "Soyuz" ships showed that an appropriate method for this purpose is registration of the atmosphere's brightness spectra near the horizon during twilight or in the daytime. On the "Soyuz-5" manned ship, Ye.V. Khrunov first recorded the brightness spectra (the change in brightness as a function of wavelength) of the twilight horizon, when it was also possible to determine the atmosphere's brightness near the horizon, where the Sun was setting, and the degree of attenuation of solar radiation by the atmosphere layer.

In time (this technique is now being perfected) these data made it possible to recover the vertical profiles of the dust concentration in the atmosphere. Work on the registration of the brightness of the diurnal horizon, which was done later on the manned spacecraft "Soyuz-7" (by V.N. Volkov) and "Soyuz-9" (by A.G. Nikolayev and V.I. Sevast'yanov), made it possible to obtain a large amount of information about the distribution of dust at different altitudes and in different areas of the globe.



In the photograph, taken by a "Meteor" satellite on 9 April 1980, it is possible to see the type of cloud field most frequently encountered over the northern part of the Atlantic Ocean.

This field of research was further developed by American scientists, who installed equipment for aerosol sensing of the atmosphere in the automatic "Sage" and "Nimbus-7" satellites. The data obtained as the result of these investigations made it possible, in particular, to follow the effects of the eruptions of the volcano Mount St. Helens, in the state of Washington, which took place in May 1980, on the aerosol content in the global stratosphere.

Sensing from space with the help of lasers (lidars) is very promising for the tracking of the atmosphere's structural parameters, small gas components and atmospheric dust.

As has already been mentioned, climate is determined by a complex interaction of processes taking place in the atmosphere, ocean, cryosphere and biosphere. We now know that information pertaining to soil and plant cover is of great importance for explaining and, moreover, predicting climate. This means that the investigation of the global cycles of different components of the environment, with special emphasis on carbon, is a very important problem.

If changes in climate can be caused by the increasing concentration of carbon dioxide of anthropogenic origin, this means that it is necessary to explain how the observed concentration of carbon dioxide in the atmosphere is formed and, on this basis, to understand how the situation may be in the future. Investigations of the global cycle of carbon for the purpose of evaluating the components of this cycle and predicting the change in the  $\text{CO}_2$  concentration in the future have, for the present, resulted in contradictory conclusions. As far as the contemporary carbon cycle on this planet is concerned, the roles of the biosphere and the world ocean have not yet been established with sufficient reliability. According to the model of the

carbon cycle advanced by V.G. Gorshkov, the ocean is such a powerful drainer of carbon dioxide (with phytoplankton playing the main role in the assimilation of  $\text{CO}_2$ ) that even if all the discovered fossil fuel were burned, the  $\text{CO}_2$  concentration in the atmosphere could not increase by more than 35-40 percent. Predictions of  $\text{CO}_2$  dynamics in the future are also complicated by the indeterminacy of the evaluations of the development of power engineering in the decades ahead. All of this determines the conditionality of predictions of future climate and the acute need for following the dynamics of the environment.

In recent years we have obtained data that show that the carbon dioxide content is affected strongly by the cutting down of forests. Even if forests that have been cut down are renewed and new forests appear in their place or the production of agricultural crops is begun in their place, the biomass turns out to be smaller than that of the original forest, which means that it processes less carbon dioxide. Once the mass of the green cover is reduced, the carbon dioxide content in the atmosphere increases.

Thus, there has now arisen a contradictory situation, the essence of which is that we still cannot explain how the carbon dioxide balance on this planet is composed and, moreover, how it will change in the future. In order to give such an explanation it is necessary, in particular, to have considerably more nearly complete information about the Earth's plant cover and its dynamics. Here, also, observations from space can be of assistance.

Within the framework of the program for manned spacecraft, the first attempts to record the spectral brightness of the plant cover from space were made. This work proved to be quite successful and showed that in the future, the taking of pictures of the plant cover from space will make it possible to have available quite complete information on the distribution of plant cover on the globe and its mass. Here use can be made of information obtained with the help of the well-known six-channel MKF-6 camera, as well as the multichannel spectrometer that has been used on manned spacecraft.

#### Global Ecological Monitoring

The obtaining of information about parameters that determine climate (temperature, pressure, moisture and so on) and the determination of the different factors that affect climatic change are frequently hindered by the effect of cloud cover if we attempt to obtain that information by using the visible and infrared wavelengths. Therefore, the use of radio methods to study the environment (and in particular for investigating climate) is becoming more and more promising. Measurements of the atmosphere's and Earth's surface's radio-thermal emissions in the centimeter band of wavelengths were first made by the "Cosmos-243" satellite in 1968. These first results indicated that the use of radio-thermal emission data was a promising field that would make it possible to obtain an idea about the water vapor content in the atmosphere, wave action in the ocean and the temperature of its surface, and the distribution of ice cover on the globe. Since then remote radio-thermal sensing has been developed very extensively and this method is now used by meteorological satellites, oceanographic satellites and natural-resource satellites. Such equipment was installed, for example, in the Soviet "Meteor-Priroda" natural-resource satellites.

Everything that has been discussed here pertains primarily to methodological developments and illustrations of existing capabilities. Meanwhile, in order to study

climate and predict it, it is necessary to have an operational satellite climate service that should be based on an appropriate system of satellites placed in polar and geostationary orbits.

The experience amassed in developing satellite meteorology and oceanography has shown that satellite measurement data are frequently difficult to decipher, since their interpretation turns out to be inadequately unambiguous. Therefore, important prospects are coupled with the creation of a system of satellite observations that would be supplemented by corresponding observations from balloons, aircraft and the Earth's surface. The creation of such a system for observing the environment, primarily for the purpose of studying climate, is a matter for the future. Right now we are testing only the separate elements of this system. Much more work remains to be done before this system becomes a real one. The experience gained in carrying out the global meteorological experiment was the first step in this direction.

One important aspect of the matter that is related to the analysis of information is that information concerning climate and the changes in it involves a very large volume of data. This requires the development of modern facilities for transmitting and processing information that utilize highly productive computers. This aspect of the matter--the terrestrial data reception and processing complex--is critically essential at the present time, precisely because the inadequate productivity of the data processing facilities makes it difficult to obtain the needed information in some cases.

#### The Climates of the Planets

One important aspect of investigations of climate and the changes in it on Earth is related to the fact that much useful information for a better understanding of the processes taking place on Earth can be obtained by studying other planets, primarily Venus, Mars and Jupiter. The need for studying these planets is determined by the fact that nature created entirely different conditions on them than on Earth. Although, shall we say, Earth is a heavenly body that is rotating comparatively rapidly, slow rotation is a characteristic of Venus. Although on the Earth's surface the atmospheric pressure equals about 1,000 hPa, on the surface of Venus it is almost 100 times greater and on Mars's surface it is about 100 times less.

Briefly, what we are saying is that the planets in the Solar System are extremely variegated models of climate formation under conditions different from those on Earth. Although, for example, the terrestrial atmosphere consists primarily of nitrogen and oxygen and its optical properties are determined by different small components, on Mars and Venus the basic component is optically active carbon dioxide. The evolution of the planets' atmospheres was specific. Although on Earth it led to the formation of a nitrogen-oxygen atmosphere, the thick atmosphere of Venus became a carbon dioxide one containing a negligible amount of water vapor (important new results that make it possible to analyze the path of evolution of the Venerian atmosphere were produced by the "Venera-13" and "Venera-14" automatic stations).

The use of these models of climate, each of which is specific, makes it possible to achieve a better understanding of how climate formation takes place on different planets and, of course, on Earth. In addition, in all this there are various interesting aspects concerning even anthropogenic effects on climate. We know, for example, that discharges of freon into Earth's atmosphere affect the ozone layer, which



also means the climate. We know that on Mars there also exists an ozone layer encircling the planet. Although on Earth the ozone layer covers the entire planet, on Mars it has a ragged structure or, more probably, there is no layer there and what we are observing are individual clouds of ozone that appear and disappear. And it is very important to understand how the formation and destruction of these ozone clouds take place under the conditions on another planet. This will make clearer the question of what can happen to Earth's ozone layer under the effect of different anthropogenic factors.

Another example of an interesting parallel is stratospheric clouds on Earth and Venus. We have known for a long time that in the Earth's atmosphere at an altitude of about 20 km there exists a layer of haze consisting of extremely small particles of a concentrated solution of sulfuric acid. As it turns out, Venus's basic cloud cover, which is also located at rather high altitudes, also consists primarily of drops of a concentrated sulfuric acid solution. The study of the processes of the formation of stratospheric haze on Earth and clouds on Venus reveals much in common in those and other processes and is mutually enriching.

In a word, the problem of climate is so broad that it takes us beyond the bounds of Earth and makes the investigation of other planets an important matter.

By studying the specific nature of these planets we will acquire the capability of understanding better what is going on on our planet.

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## INVESTIGATING SPECTRAL TRANSPARENCY OF CRYSTALLINE CLOUD MEDIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
No 5, May 83 (manuscript received 28 Dec 81, after revision 12 Jul 82)  
pp 497-503

VOLKOVITSKIY, O. A., KUZNETSOV, V. V., PAVLOVA, L. N., PETRUSHIN, A. G. and  
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[Abstract] The article gives the results of investigation of the influence of size and shape of crystals on spectral attenuation in the range 0.4-14  $\mu\text{m}$ . The investigation involved measurement of the attenuation indices in media with a monitorable microstructure and a comparison of the results of measurements with computations of the attenuation of radiation by ice particles. The measurements were made in a cold chamber with a volume of 100 m<sup>3</sup>. For determination of the phase state of the fogs created in the chamber use was made of the method for measuring the depolarization ratio  $D$  in the back-scattered signal with irradiation of the particles by plane polarized radiation; all cases with  $D_{\parallel} > 0.4$  are classified as crystalline media. The shape of the forming crystals was determined by the replicas method and the size and concentration using an "Aspekt-10" 9-channel TV spectrometer whose sensor was placed near the optical measurement path. Spectral transparency in the range 0.4-1  $\mu\text{m}$  was measured using an MDR-2 monochromator and in the range 1-4  $\mu\text{m}$  with an IKS-21 spectrometer. The radiation sources were at a distance of 4 m from the receiver. The radiation was collimated into a parallel beam and directed through the chamber window to a mirror objective which focused the radiation on the monochromator slit. The spectral variation of the attenuation indices was investigated by simultaneous measurements of transparency in the mentioned spectral ranges and at 0.63  $\mu\text{m}$ . The measurements gave the effective attenuation factor in the IR spectral range for three models of a medium consisting of polydisperse ice particles: spheres, platelets and cylinders with a ratio of axes greater than 10. The influence of the size and orientation of aspherical particles on the spectral variation of attenuation of radiation is demonstrated. Comparison of computed and measured data for crystalline media reveals a qualitative agreement. A difference in the spectral dependences of the attenuation index in droplet and crystalline clouds should be manifested only in the region of wavelengths 9.5-12.5  $\mu\text{m}$ . Figures 5; references 16: 9 Russian, 7 Western.  
[161-5303]

## MODELING INFLUENCE OF STRATOSPHERIC TEMPERATURE CHANGES ON GROWTH OF SULFATE AEROSOL DROPLETS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 5 Jan 82) pp 504-512

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[Abstract] The authors use a numerical homogeneous model for describing the condensation growth of droplets of stratospheric sulfate aerosol accompanying fluctuations of stratospheric temperature and the characteristic time of this process is estimated. It is shown that in the polar regions in summer there can be distillation of the liquid phase from small droplets whose size is less than the critical size onto large droplets. There is a conspicuous tendency to growth in the mean size of the droplets. Warming of the stratosphere by 5-8°C (as is observed after major eruptions of volcanoes) considerably intensifies this process. In the middle latitudes the distillation effect is less conspicuous and it is absent in the equatorial regions due to very low temperatures. The activation of a source of sulfuric acid vapors of a low intensity, corresponding to background conditions, slows the distillation process and powerful sources simulating the state of the stratosphere after the eruption of volcanoes completely smooth the influence of the temperature regime. After volcanic eruptions, as a result of increase in the quantity of  $H_2SO_4$  vapors in the stratosphere, at all latitudes there should be a substantial increase in the size of all particles. During periods of quiet there can be an increase in the sizes of the large-droplet fraction of aerosol particles. This phenomenon should be expected for the most part in the polar regions. Figures 3, tables 1; references 22: 7 Russian, 15 Western. [161-5303]

GLOBAL MODEL OF OCEAN-ATMOSPHERE SYSTEM AND INVESTIGATION OF ITS RESPONSE TO CHANGE IN  $CO_2$  CONCENTRATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 28 Dec 81, after revision 18 Jun 82)  
pp 451-458

ALEKSANDROV, V. V., ARKHIPOV, P. L., PARKHOMENKO, V. P. and STENCHIKOV, G. L.,  
Computation Center, USSR Academy of Sciences

[Abstract] The article describes a numerical model of circulation of the atmosphere and upper layer of the ocean used in investigating changes in the earth's climate. A coarsest computation grid of  $12 \times 15^\circ$  with parameterization of eddy transport was used. The model provides for the possibility of using different time scales for the ocean and atmosphere. The model was employed

for a preliminary investigation of the influence of change in the content of atmospheric CO<sub>2</sub> on the earth's climate. Quasistationary states corresponding to the present-day, doubled and quadrupled levels of the content of atmospheric CO<sub>2</sub> were computed. In these experiments the flux of solar radiation incident on the upper boundary of the troposphere, the distribution of snow and sea ice were considered to be not dependent on time and equal to their corresponding mean annual values. The geographical distributions of the mean annual air temperature at the underlying surface obtained from the results of observations and numerical integration are shown in Figures 1,a and 1,b. Figure 2 shows the mean zonal wind distributions at the levels 400 and 800 mbar obtained from observations and computations. Computations were made for the global mean values of atmospheric temperature, air at the underlying surface, the underlying surface itself, the rate of falling of precipitation and the flux of short-wave radiation through the underlying surface for regimes with a present-day, doubled and quadrupled atmospheric CO<sub>2</sub> content. A map of the change in air temperature at the underlying surface with a doubling of the CO<sub>2</sub> content is shown as Fig 5,a; Fig. 5,b is a corresponding map of air temperature change at the underlying surface resulting from a quadrupling of CO<sub>2</sub> content. It is shown that the response of the model to a change in the concentration of atmospheric CO<sub>2</sub> is already nonlinear with a doubling of the CO<sub>2</sub>. A comparison is made with the computations of other authors. Figures 5, tables 1; references 12: 4 Russian, 8 Western.  
[161-5303]

UDC 551.515.5:551.511.3

# NUMERICAL MODEL OF TROPICAL CYCLONE WITH COMPUTATION OF CONDENSATION AT GRID-RESOLVED SCALES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 11 Feb 82) pp 459-466

KHAIN, A. P., USSR Hydrometeorological Center

[Abstract] Until recently the use of traditional methods for the parameterization of convection has been regarded as necessary for obtaining the real structure of a model hurricane. M. Yamasaki was the first to demonstrate that this could be avoided and S. L. Rosenthal later appeared to confirm this. The author of this article has endeavored to demonstrate clearly whether or not the real structure of circulation in a model of a tropical cyclone can be obtained without using the traditional methods of parameterization of convection when using a considerable horizontal interval (60 km) of the finite-difference grid. The investigation was made with an 11-layer axially symmetric model of evolution of a tropical cyclone developed at the USSR Hydrometeorological Center. A series of numerical experiments was carried out. It was found that a tropical cyclone structure of circulation can be obtained successfully when using a nonparameterized description of convection even when employing such a coarse grid interval. Finally, the author seeks to explain the reasons for failure to obtain a hurricane structure in many earlier models. None of this means that the parameterization of convection should be completely excluded in such modeling, but with the state of the art it remains a rather arbitrary procedure. Figures 5, tables 1; references 18: 4 Russian, 14 Western.  
[161-5303]

## LONG-PERIOD ATMOSPHERIC OSCILLATIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 4, Apr 83 (manuscript received 30 Nov 81, after revision  
24 Sep 82) pp 339-347

TEPTIN, G. M., Kazan' University

[Abstract] "Long-period" oscillations in the earth's atmosphere are defined as those for which the changes in parameters have periods greater than a month. Description of such long-period oscillations requires use of the equations of hydrothermodynamics written for a spherical earth. Here the author examines a smooth earth having an atmosphere of adequately great height (but small in comparison with the earth's radius). A study was made of 134 monthly series of mean monthly temperatures for 450 stations in the northern hemisphere, distributed approximately uniformly over the hemisphere. The amplitudes and phases for a number of stipulated frequencies were found by the least squares method using initial series of data from 1920 through 1940 for all 450 stations. Then the 134-month series of initial values was shifted one month forward and the analysis was repeated (although this was done only for 10 years). It was found that there is a rather great number of dominating periodicities in the temperature series in the range of periods 2-160 months. There is a relatively low amplitude and high temporal and spatial variability of both the amplitude and phase of the long-period oscillations. All these properties are characterized by definite difficulties in their detection and study. The most important of the detected periodicities are also characteristic of the spectra of other meteorological elements. Figures 5; references 20: 17 Russian, 3 Western.  
[139-5303]

## METHOD FOR COMPUTING NATURAL COMPONENTS OF METEOROLOGICAL FIELDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 4, Apr 83 (manuscript received 5 Oct 81, after revision 9 Feb 82)  
pp 348-356

DATSENKO, N. M., PERFILOV, V. I. and SONECHKIN, D. M., Hydrometeorological Center

[Abstract] The article describes a new method for computing the natural components of meteorological fields stipulated by a sample of their observations at fixed points whose number can be very great. In the application of this method with an electronic computer the required volume of the operational memory is of the order of  $2p$  in comparison with the requirement of  $p^2$  for earlier used methods. The basis of the method is the process of stochastic

approximation of the maximum eigenvector of a symmetric positively determined matrix, being the mathematical expectation of some random matrix for which the T. P. Krasulina theorem is demonstrated (T. P. Krasulina, "Stochastic Approximation Method for Determining the Maximum Eigenvalue of the Mathematical Expectation of Random Matrices," AVTOMATIKA I TELEMEXHANIKA, No 2, pp 50-56, 1970). The statistical properties of the evaluations of the natural components and the corresponding eigenvalues are analyzed for samples of a finite volume. Application of the method is illustrated in examples, followed by reliability evaluations. Figures 3; references 19: 6 Russian, 13 Western. [139-5303]

UDC 551.521.31:551.576

#### REFINING RADIATION MODEL OF STRATIFORM CLOUD

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 4, Apr 83 (manuscript received 19 May 80, after revision 7 Jul 82) pp 382-389

KARGIN, B. A. and TROYNIKOV, V. S., Siberian Division, Computation Center, USSR Academy of Sciences

[Abstract] Recent investigations have led to the publication of a number of new, better-validated radiation models of stratiform clouds. Some of the results have been published in the monograph RADIATSIYA V OBLACHNOY ATMOSFERE, edited by Ye. M. Feygel'son, Leningrad, Gidrometeoizdat, 1981, 280 pages. There and in most earlier studies the evaluations of the pertinent characteristics were obtained with a very rough allowance for the spectral change of the scattering function. Accordingly, the authors have sought to supplement the materials presented in the above-mentioned review by an analysis of the influence of vertical inhomogeneity on the albedo and absorptivity of stratiform clouds. Comparative data are also given on the radiation characteristics of cloud layers obtained with more precise allowance for the spectral change in optical parameters. The Monte Carlo method is used in analyzing the results of computations of albedo and absorptivity of vertically homogeneous and inhomogeneous cloud layers in the visible and near-IR regions of the solar spectrum. The influence of the vertical stratification of liquid-water content, humidity and attenuation coefficient is evaluated, as well as the spectral dependence of optical parameters on the albedo and absorptivity of clouds. In the first case this influence is weak; in the second case it can be somewhat greater. Tables 3; references: 5 Russian. [139-5303]

## POSSIBLE NATURE OF PRETHUNDERSTORM ELECTROMAGNETIC EMISSION OF CONVECTIVE CLOUDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 4, Apr 83 (manuscript received 31 Mar 80, after revision 2 Nov 81) pp 438-442

IMYANITOV, I. M. and MOROZOV, V. N., Main Geophysical Observatory

[Abstract] The existence of prethunderstorm radioemission of convective clouds has been established. Such emission is observed in the stage of cloud development even before clearly expressed electrical processes in clouds can be detected. This electromagnetic emission (EME) possibly arises in small zones in which intensive electrical processes transpire. It is also possible that the EME is unrelated to discharge activity in the cloud but with the reradiation of EME arriving from other sources in cloud particle concentration gradients. The latter hypothesis is supported by the fact that prethunderstorm EME arises in the stage of cloud development when there is an increase in inhomogeneities associated with the falling of precipitation. These different possibilities are explored here in depth. Computations are given showing that the scattering of EME due to the regular inhomogeneous distribution of cloud particles can play an important role in pre- and post-thunderstorm emission of convective clouds. A possible model is proposed. It is shown that the presence of many cloud inhomogeneities can lead to the appearance of a great many random impulses and the formation of nonlightning EME. It is determined by the time of formation of the cloud inhomogeneities associated with appearance of the solid phase, the process of enlargement of cloud particles and the falling of precipitation. In the absence of any of these components the proposed model will not fit. Figures 1; references: 10 Russian.

[139-5303]

UDC 551.464.34+551.465.74(268)

## EXCHANGE OF OXYGEN AND CARBON DIOXIDE BETWEEN ARCTIC OCEAN AND ATMOSPHERE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 1, Jul 83 (manuscript received 29 Dec 82) pp 198-201

LYAKHIN, Yu. I. and RUSANOV, V. P., Leningrad Hydrometeorological Institute; Arctic and Antarctic Scientific Research Institute, Leningrad

[Abstract] Results are reported from calculations of gas exchange in the Arctic Ocean, the specifics of which are defined by the details of its physical and geographic conditions: low mean annual temperature of surface water and presence of ice cover practically year round. The annual gas exchange budget between the ocean and the atmosphere is calculated, using

equations for summer and for winter. On the mean annual scale the Arctic Ocean and North Atlantic seas serve as a constant oxygen and carbon monoxide sink. Absorption of oxygen by these seas facilitates the ventilation of deep ocean waters. The total annual flow of  $\text{CO}_2$  into the Arctic Ocean is not great in comparison to the total annual flow for the entire ocean, indicating the slight contribution of the Arctic Ocean to the removal of excess carbon dioxide from the atmosphere. References 9: 7 Russian, 2 Western.  
[197-6508]

UDC 551.524(215-17)

DETERMINATION AND PREDICTION OF NORTHERN HEMISPHERE TEMPERATURES BASED ON  
FLUCTUATIONS IN TREE GROWTH INDICES AT THE POLAR TREE LINE

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 4, Jul-Aug 83 (manuscript received 25 Oct 82) pp 41-47

BERRI, B. L., LIBERMAN, A. A. and SHIYATOV, S. G.

[Abstract] This work utilizes data on the radial growth of trees as a temperature predictor. Tree growth ring size is influenced by temperature, precipitation, groundwater level and mineralization, slope exposure, etc. The relationship between tree growth and climatic parameters is therefore not always unambiguous. However, this phenomenon does allow selection of a group of model trees, the growth of which is determined primarily by one of the above factors. The growth of trees at the polar limit of the forests depends primarily on the mean temperature of the summer months. For a number of observations, the mid-July temperatures at Salekhard extending over the past 90 years correlate well with a number of growth indices of the Siberian stone pine. Model trees were selected from dry habitats in the lower reaches of the Ob' River. The time sequence of growth indices was approximated by 12 harmonics selected by computer. The mean annual air temperatures in the northern hemisphere are predicted in connection with the hypothesis of a possible catastrophic warming in the early 21st century due to anthropogenic effects on the climate. In accordance with the prediction of natural climatic changes, a sharp drop in mean annual northern hemisphere temperatures would be expected during both the last decade of the 20th century through the mid-21st century. The results of these studies do not confirm previously reported nascent anthropogenic warming. A temperature minimum is predicted for 1995, after which the temperature will begin to rise again, reaching its previous level in another 8 or 9 years. This prediction can be considered a natural standard with which the actual temperatures can be compared in the future to determine any anthropogenic warming trend. Figures 3; references 14: 13 Russian, 1 Western.  
[188-6508]



## OCEANOGRAPHY

### IMPROVED TSUNAMI WARNING SERVICE IN MARITIME KRAY

Moscow VODNYY TRANSPORT in Russian 25 Jun 83 p 4

[Article by special VODNYY TRANSPORT correspondent L. Stukun: "Tsunami: The Second Attack, Our Detailed Report"]

[Text] During the second half of June 21, the southeeastern coast of Primorskiy Kray was hit by a tsunami.

It seems like it was only yesterday that these same shores—enterprises and settlements from Pos'yet in the extreme south to Velikaya Kema in the north—were dealt a crushing blow by an overpowering wave which came crashing down on them at the peak of the working day almost a month ago.... But now once again, as was the case on May 26, a tsunami has been generated by an underwater earthquake several miles off the Japanese island of Hokkaido.

Let's now go back to that day in May. At two o'clock in the afternoon, the Sakhalin seismological service recorded a shock in the Earth's crust under waters off the coast of Hokkaido. A sharp change in the bottom relief set an entire mass of water in motion on the surface of the ocean. It generated waves, which then began to spread in concentric circles, gathering strength and speed as they traveled. What with the fact that we have had experts all along the front of the tsunami, it has today been possible to measure its speed and, accordingly, its force, with the greatest possible accuracy: 170 meters per second! That was the speed with which the first wave sped toward the shores of the Primor'ye, a speed that took it across the Sea of Japan in something like half an hour....

There's no need, of course, to point out the fact that the working day was in full swing at this hour in the coastal settlements and fish processing combines in the area.... Kamenka, Rudnaya pristan', Valentin, Preobrazheniye, Yuzhnomorskoy—these Primor'ye settlements, settlements in which fishermen and seamen live and work, were the first to feel the full force of the tsunami. Six- and eight-meter waves whirled small fishing seiners around in frothing whirlpools like toys and heaved them onto the rocks....

It is still today virtually impossible to predict earthquakes with the same accuracy as was achieved on the occasion when the eruption of Kamchatka's Tolbachik was predicted within just a few hours before the event. A submarine earthquake capable of generating a tsunami can occur at any minute in any of the

seismically dangerous regions of the Pacific Ocean, which would first and foremost include the Japanese islands. To "hear" one, precisely determine its coordinates by drawing on experience, consulting the "tsunami atlas" and taking account of the relief of the seabed in the area, establish the direction the tsunami was taking and the front along which it was propagating and, most importantly, to alert tsunamigenic regions of the threatening danger—this is the job of the seismologists and the natural disaster warning service based on Sakhalin.

Primor'ye residents were quite simply unprepared for the first tsunami. But the thrashing they took in May taught them a painful but valuable lesson. To be more effective in the case of a tsunami, their warning system would require substantial improvement; it had to be more mobile, easier to manage and more efficient.... The Primor'ye has a system like this now. And the second tsunami put it to the severest of tests.

When on June 21 seismologists on Sakhalin recorded a submarine shock in the vicinity of the island of Hokkaido and, after determining the coordinates of the epicenter and the front along which the tsunami was propagating, alerted the Primor'ye's hydrometeorological and environmental monitoring administration of the threatening danger, the warning system went into operation. The warning was immediately transmitted in accordance with a prearranged plan to all coastal enterprises and local soviet and party organizations. The entire coastal region was in fact alerted within half an hour. Enterprises near the shoreline itself shut down their operations. All ships left their anchorages and headed out in the direction of the wave.

The submarine shock had been recorded at 1740. Within an hour and a half the first wave hit the coast of the Primor'ye. Fortunately, the seaquake had been a small one. It fell one point shy of the May tsunami on the force scale. The water level on the Primor'ye coast peaked at only two meters. At 2115 Moscow time the tsunami service gave the "all clear" signal. The tsunami front had in fact reached the coast in the region but had done no damage. People in Vladivostok could see the tsunami reflected in a slight rocking of the ships there.

The tsunami warning service now continues its round-the-clock watch. The Pacific Ocean is seldom peaceful.

8963  
CSO: 5000/148

CRUISES OF FISHERIES RESEARCH SHIP 'AKADEMIK KNIPOVICH'

Moscow RYBNOYE KHOZYAYSTVO in Russian No 7, Jul 83 pp 14-16

[Article by Doctor of Geological-Mineralogical Sciences D. Ye. Gershanovich and Candidate of Biological Sciences T. G. Lyubimova, VNIRO (All-Union Scientific Research Institute of Marine Fishing and Oceanography): "Chronicle of Fisheries Research: Twenty Expeditions of NPS (Fisheries Research Ship) 'Akademik Knipovich'"]

[Text] The VNIRO fisheries research ship "Akademik Knipovich" became one of the operating research vessels of the USSR Minrybkhhoz [Ministry of the Fish Industry] in 1964. Constructed on the base of a large refrigerated fishing trawler and outfitted with everything necessary for performing research and experimental fisheries work in the ocean, the NPS "Akademik Knipovich" was the first among such ministry vessels and played an important role in identifying resources, studying the biological productivity of the ocean, and developing ocean fisheries in our country. A number of voyages were made jointly with scientists of coastal states.

While on an extended cruise the vessels of this class were to provide for accomplishing practically all basic kinds of scientific research, obtaining a sufficiently complete description of fishing areas and targets, and performing experimental fishery and technological work. Fitting the ship with fishing equipment, industrial equipment, and refrigeration units allowed the delivery of test lots of finished products on returning from a voyage.

The expeditionary voyages of the NPS "Akademik Knipovich" marked the beginning of a new stage of ocean fisheries research. Twenty expeditions by this vessel as well as research by similar vessels of basin institutes and surveys and, somewhat later, work similar in direction to studies by fisheries research vessels built on the basis of the RTM [refrigerated ship and fishing trawler] "Atlantik" ("Professor Mesyatsev," "Evrika," and others) was aimed at further identification and development of the ocean's biological resources, an expansion in ocean fisheries, and the development of fishing in open waters of the World Ocean.

A trial voyage of the NPS "Akademik Knipovich" was made in the northwestern part of the Black Sea during October-November 1964. A group of VNIRO scientists tested the vessel at shallow and great depths, tested the operation of fishing and industrial arrangements and deemed her suitable for normal

operation in conformity with her missions. The first expedition's research program was prepared by its future participants--Yu. Yu. Marti (expedition chief), D. Ye. Gershanovich, D. A. Shubnikov, A. A. Yelizarov, Yu. Ye. Permitin and others. The expedition planned for research in the tropical Atlantic, in the Scotia Sea and in zones of the Falkland and Benguela currents, and a return through the Indian Ocean. This program was completely fulfilled. The vessel (captain-director A. N. Basalayev) left Sevastopol in December 1964 and was at sea for over seven months. During this time very abundant fisheries research material was collected in the Atlantic sector of the Antarctic (up to 64° south latitude in the Weddell Sea), in the Falkland (Malvinas)-Patagonian region, near southwestern Africa in the upwelling zone and along the east coast of Africa. The first expedition showed the effectiveness of the studies performed for fisheries research purposes.

From December 1965 through May 1966 the II Expedition (chief A. S. Bogdanov) operated in the northern part of the Indian Ocean, including in shelf waters of Hindustan, the Bay of Bengal and the Andaman Sea. New fisheries research data were obtained in monsoon and certain equatorial areas.

The III Expedition (chief V. A. Borodatov), which worked in the Antarctic during 1966/1967, played an essential role in ocean research. The thorough study of biological resources of the Scotia Sea and regions adjoining it on the north made the development of fisheries in this part of the Atlantic Ocean realistic. The "mramornaya nototeniya" became a new fisheries target.

Antarctic studies were continued and expanded during 1967-1970 during the VII and IX expeditions (scientific director A. V. Lestev). Comprehensive oceanological, hydrobiological, ichthyological and exploratory work, which now has become traditional for VNIRO Antarctic studies, was accomplished. Much attention was given to techniques of catching fish, to an improvement in fishing equipment and methods, and to industrial processing of raw materials.

Successes of the lengthy VNIRO scientific expeditions aboard the NPS "Akademik Knipovich" and the methodological substantiation and effectiveness of organizing the research prompted the FAO [Food and Agricultural Organization of the United Nations] to conduct a series of special joint expeditions together with VNIRO for the training and practical experience of specialists from the developing countries. Scientists of almost 50 countries took part in them. The first such expedition (the IV Expedition of the NPS "Akademik Knipovich") operated in the Black Sea (chief V. A. Borodatov) in 1967 and the VI (chief A. V. Lestev) in the Black and Mediterranean seas in 1968. The VIII Expedition (chief A. S. Bogdanov) was larger and longer. The biological productivity and resources of selected areas of the tropical Atlantic and the Gulf of Mexico were studied during that expedition. In 1970 comprehensive research involving the participation of scientists from the developing countries was carried out on the X Expedition of the NPS "Akademik Knipovich" (chief A. S. Bogdanov) near northwest Africa. The materials of these expeditions were published repeatedly by FAO.

In addition to lengthy and basic scientific fisheries work in the Scotia Sea, oceanological, ichthyological and exploratory research was conducted in the

South Atlantic in areas adjoining Bouvet Island during 1971/1972 on the XI Expedition (chief A. V. Kardashev). More extensive research began in Antarctic waters beginning in 1972. The purpose of the XII (1972/1973) and XIV (1974/1975) expeditions under the direction of T. G. Lyubimova, along with the traditional set of studies in the Scotia Sea, was a study of the productivity and resources west of the Scotia Sea. During the XII Expedition much attention also was given to a study of Pacific Ocean waters in the eastern zones of the southern temperate latitudes.

During the summer of 1974 on the XIII Expedition (chief D. Ye. Gershanovich) fisheries research was performed in the Canary region of the Atlantic Ocean. The set of projects was supplemented by a study of conditions of habitat of the fishes near certain seamounts typical of this area. Participants of the XV Expedition (1975/1976) under the direction of A. V. Lestev basically conducted fisheries research in areas adjoining the Antarctic peninsula.

The Scotia Sea, Bellingshausen Sea and vast areas between them were studied thoroughly during the XVI Expedition (chief T. G. Lyubimova) in 1977/1978. Fisheries research was performed on the XVII Expedition (chief M. A. Bogdanov) during 1978/1979 in these same Antarctic waters as well as in the northern part of the Weddell Sea. Completely new data were obtained on the biological productivity and fishery targets in the vast zone from Bouvet Island to the Bellingshausen Sea as a result of many years of work under very difficult Antarctic conditions. Of primary importance was the opportunity of comparing the distribution of organisms and the variability of conditions and the fishery based on the data of observations of climatic and oceanological characteristics in various years.

On the XVIII Expedition (chief M. A. Bogdanov) in 1980 studies were performed in the tropical part of the Pacific Ocean in the zone of waters of the southern tropical divergence. Detailed materials were collected on the structure of waters and biological productivity and, of particular importance, the significance of the oceanic upwelling was determined in the overall structure of dynamics of the waters in this area.

Studies have been continuing aboard the NPS "Akademik Knipovich" in Antarctic waters since 1981. During the XIX Expedition (chief Ye. V. Vladimirskaia) a set of fisheries research projects was carried out in the Lazarev and Scotia seas and to the west of the Scotia Sea, and during the XX Expedition in 1982 (chief A. N. Kozlov) there was a study of the Amundsen Sea, the area of the southern polar front west of the Drake Passage and areas near the Antarctic peninsula.

The total amount of scientific research performed on the 20 expeditions aboard the NPS "Akademik Knipovich" is colossal. Although the research basically was directed at a comprehensive study of Antarctic waters and resources, the geography of the expeditions is very broad. Studies were performed in all zones of the ocean from equatorial to polar. Data contributing to the development of corresponding scientific directions were obtained in all kinds of research--oceanological, hydrobiological, ichthyological, exploratory, fisheries techniques, and the technology of processing raw material. New species and genres of fish were discovered on the basis of data obtained during the

expeditions of the NPS "Akademik Knipovich" in Antarctic waters and fundamental oceanological, ecological and biogeographical conclusions were drawn which became the basis for a fundamentally new approach to the study and practical development of the resources of waters in Antarctic latitudes and certain other ocean areas. Methods of scientific exploration and fisheries research work were perfected and a school for highly skilled researchers was formed on expeditions of the NPS "Akademik Knipovich." All scientific research aboard the NPS "Akademik Knipovich" took place with the most active support and participation of the ship's crew. From 1966 through 1976 the captain-director of the NPS "Akademik Knipovich" was A. G. Petukhov, and later it was G. M. Il'gov, L. A. Skorokhodov and S. I. Petrik.

In the 20 expeditions the ship covered some 500,000 nm, accomplished thousands of oceanological observation series and trawlings, obtained numerous samples of plankton, benthos, ichthyofauna and so on, and explored almost four million square kilometers of water area. The NPS "Akademik Knipovich" continues to be in operation and is preparing for further expeditionary work on the World Ocean.

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6904

CS0: 1865/198

NEW RESEARCH SHIP TO EXPLORE FOR MANGANESE NODULES

Kiev RADYANS'KA UKRAYINA in Ukrainian 9 Aug 83 p 1

[Text] Nikolayev, 8 August. At the Chernomorsk Shipyard the construction of a new type of vessel, the "Morskoy Geolog", is nearing completion. The ship will be floating geological-geographic branch of the USSR Ministry of Geology for exploration and scientific research. It will explore the bottom of the oceans and seas to locate concentrations of iron-manganese nodules suitable for mining.

The "Morskoy Geolog" will have exploration equipment, 22 laboratories and a computer center. It will have a staff of 43 scientific workers. The "Morskoy Geolog" will be able to take bottom samples from practically any depth. The ship will take part in an international exhibit of geophysical ships.

CSO: 1865/203

UDC 551.558.1:551.465.72

#### CONVECTIVE COOLING OF FLUID FROM FREE SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 5 Jul 82, after revision 6 Dec 82)  
pp 513-523

GRACHEV, A. A., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] In an earlier study (G. S. Golitsyn and A. A. Grachev, DOKL. AN SSSR, Vol 255, No 3, pp 548-552, 1980) the authors proposed parameterization of the fluxes of apparent and latent heat during free convection over a water surface by means of the water-air temperature difference and humidity distant from the surface. In that study the parameterization of the moisture flux was checked experimentally. In this new article, using the material in the earlier study as a point of departure, the authors derive expressions for the dependence of the temperature of a fluid cooling from the surface on time and these expressions are checked experimentally. The investigation was made for two different ranges of water-air temperature differences. With temperature differences from  $\sim -0.5$  to  $\sim 10^\circ\text{C}$  the temperature of the cooling fluid decreases approximately exponentially with time, whereas in the range of temperature differences from  $\sim 10$  to  $\sim 30^\circ\text{C}$  the fluid cools cubically. The good agreement of the results of theory and measurements serves as an independent confirmation of the correctness of the parameterization developed earlier but is also of independent interest for geophysicists and heating engineers. Figures 5, tables 1; references: 9 Russian.  
[161-5303]

UDC 551.466.31

#### METHOD FOR COMPUTING SWELL RESONANCE FRONTAL WAVES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 15 Feb 82) pp 551-554

MATUSHEVSKIY, G. V., State Oceanographic Institute

[Abstract] Observations of 1973 in the Black Sea in the Sochi region revealed a new source of generation of short waves at the water surface--moving atmospheric cold fronts. The existence of such waves, which can be called swell



resonance frontal waves, has been confirmed by observations in other seas and oceans, but particularly in the neighborhood of Cape Town. "Strange" waves have occurred there which have caused damage even to very large ships. A physical explanation was later given for the mechanism of generation of these waves (they are caused by atmospheric pressure fluctuations in the zone of a cold front where the energy level of turbulence is increased due to the great temperature contrast between the air and the underlying surface). An equation has been derived which has made possible a qualitative investigation of the form of the frequency spectrum and an explanation of the main features of the studied phenomenon. It is shown that with the passage of a front there should be generation primarily of waves with frequencies in the region of the peak  $\omega_r = g/U$  and in the spectrum there should be a narrow maximum. The effect of generation of resonance waves should be manifested most clearly with large velocities of movement of the front. The distribution of the heights of frontal waves is narrower in comparison with the Rayleigh distribution and the maximum wave heights are approximately twice as great as the mean heights. Therefore the maximum heights are 16-18 m; the steepness of the highest waves is about 1/30. The mean period of the waves is approximately 0.8 of the period of the maximum in the spectrum of resonance waves. Two expressions are derived which make it possible to evaluate the two principal parameters of swell resonance frontal waves and can serve for prognostic purposes. References 12: 7 Russian, 5 Western.

[161-5303]

UDC 551.466.2

#### ATTENUATION OF OCEAN SURFACE WAVE CAUSED BY RADIATION OF WAVES INTO ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 7 Dec 81) pp 554-557

PAVLOV, V. I. and SLABEYTSIUS, Yu., Moscow State University

[Abstract] The authors have evaluated the effectiveness of interaction of surface waves with the atmosphere. As a result of this interaction the surface wave generates internal gravity waves in the atmosphere. By determining the intensity of the radiation it seems possible to evaluate the characteristic time of wave attenuation. The radiation of a wave into the atmosphere is possible only if the phase velocity of the generated perturbations is less than the velocity of the surface wave. The characteristic time of wave attenuation was computed for different values of the parameters. The radiation for the most part is at an angle of about  $40^\circ$  to the horizon. With an increase in the angles the intensity of the radiation drops off exponentially. The results presented in the paper are to a considerable extent qualitative but the considered mechanism can play a significant role in the process of relaxation of surface waves. The characteristic attenuation time, computed within the framework of the selected model, does not contradict the observational data. Figures 1; references: 6 Russian.

[161-5303]

## PARAMETERS OF LOMONOSOV CURRENT MEANDERING

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
 No 5, May 83 (manuscript received 10 Feb 81, after revision 22 Feb 82)  
 pp 557-559

BUBNOV, V. A., Institute of Oceanology, USSR Academy of Sciences

[Abstract] The author gives an evaluation of the parameters of the Lomonosov Current on the basis of data from a quasisynoptic hydrological survey. Pertinent data were collected during the 29th voyage of the "Akademik Kurchatov" during a period of almost two months on runs along 18°30' and 23°30'W during the period 11-22 August 1979, in general covering the area between parallels 2°N and 2°S. There were 7 meridional runs separated by 1°15' in longitude. The observational data were used in plotting maps of hydrological characteristics reflecting the meandering of the Lomonosov Current. The latitudinal position of the core of the Lomonosov Current is usually determined from the maximum salinity in the layer of its subsurface maximum. During the period of the survey the axis of the current was displaced 20-40 miles to the south of the equator and experienced fluctuations in latitude from run to run. These fluctuations had the form of a wave perturbation. The meanders can be regarded as plane sinusoidal waves propagating rigorously in a zonal direction along the equator. There are two possible variants of parameters of equatorial waves. The eastward propagating wave can be a Kelvin wave generated along the shores of South America and trapped by the equatorial waveguide. The western variant of propagation of meanders can be interpreted as an equatorially trapped Rossby wave. However, for an unambiguous determination of the direction of propagation of the equatorial waves it is necessary to carry out a hydrological survey from two ships moving along the equator in opposite directions. Figures 1; references 4: 2 Russian, 2 Western.  
 [161-5303]

UDC 551.521.3:551.463.5:535.36

## CHARACTERISTICS OF RESTRICTED LIGHT BEAM IN ABSORBING MEDIUM WITH NARROW SCATTERING FUNCTION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
 Vol 19, No 4, Apr 83 (manuscript received 22 Sep 81, after revision 17 Feb 82)  
 pp 400-405

DOLIN, L. S., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] In the propagation of a light beam through a medium with a highly anisotropic scattering function and quite high absorptivity the angular distribution of brightness everywhere retains a high anisotropy. Computations of some important integral characteristics of the radiation field are possible

using a simple diffusion equation which is easily solved (within limits) if the scattering of photons is not taken into account. The restrictions on applicability of such a solution were in large part eliminated in the work of A. G. Luchinin (IZV. VUZov: RADIOFIZIKA, Vol 14, No 12, 1971; IZV. AN SSSR: FAO, Vol 10, No 12, 1974), in which photon scattering is taken into account. Unfortunately, his solution has been too complex in form, for its analysis requiring numerical Fourier transforms and the summation of series. The purpose of the author here is to demonstrate that by use of the equation proposed by Luchinin in the second of the studies mentioned above it is possible to obtain a very simple and physically graphic solution of the considered problem. Thus, the article gives an analytical solution of the small-angle diffusion equation describing the radiation field of a spatially restricted directed light source in a medium with highly anisotropic scattering and adequately great absorptivity with photon scattering by paths taken into account. Figures 1; references 13: 10 Russian, 3 Western.  
[139-5303]

UDC 551.465.53

#### EFFECT OF BOTTOM RELIEF ON STABILITY OF TWO-LAYER JET FLOW

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 4, Apr 83 (manuscript received 18 Nov 81, after revision 12 Aug 82) pp 417-423

ABRAMOV, A. A., BLATOV, A. S. and UL'YANOVA, V. I., Moscow State University

[Abstract] Both the  $\beta$ -effect and bottom topography separately exert a stabilizing effect on a current, but in combination they can be destabilizing. This problem has been explored in the literature, but many important effects have not been taken into account. For example, in an investigation of the stability of two-layer currents it is necessary that horizontal velocity shear be taken into account in both the upper and lower layers. Orientation of the current in the  $\beta$ -plane is important, especially in models where allowance is made for transverse bottom slope. Accordingly, here the authors investigate the influence of transverse bottom slope on the stability of a two-layer jet current taking into account the differences in density and thickness of the upper and lower layers, horizontal velocity shear in both layers and flow orientation in the  $\beta$ -plane. The article gives computations of stability diagrams with different parameters with a determination of the neutral curve and computation of the eigenfunctions for the amplitude of pressure of unstable perturbations. It is shown that in the case of weak vertical stratification a constant bottom slope, regardless of its sign, exerts a stabilizing effect. On the stability diagrams there are three zones corresponding to different types of instability leading to the appearance of wave perturbations with different phase velocities and vertical structure. Model computations are compared with in situ data. Figures 4; references 11: 6 Russian, 5 Western.  
[139-5303]

# CONSTRUCTION OF THE CRUST OF THE SHATSKIY AND HESS SUBMARINE ELEVATIONS (PACIFIC OCEAN) BASED ON SEISMIC SURVEY-REFLECTED WAVE METHOD DATA

Moscow BYULLETEN'MOSKOVSKOGO OBSHCHESTVA ISPYTATELEY PRIRODY: OTDEL GEOLOGICHESKIY in Russian Vol 58, No 4, Jul-Aug 83 (manuscript received 9 Feb 82) pp 15-29

KOGAN, L. I., ZONENSHAYN, L. P. and SHMIDT, O. A., Institute of Geology, USSR Academy of Sciences, Moscow; Southern Division, Institute of Oceanography, USSR Academy of Sciences, Gelendzhik

[Abstract] A new system of geological and geophysical studies was performed on the Shatskiy and Hess submarine elevations in the Pacific Ocean in 1978-1979 during two voyages of the research vessel "Dmitriy Mendeleyev", including multichannel deep seismic profiling. These were the first deep seismic profiling reflected wave method studies performed in the area. Methods and equipment used, and characteristics of seismic cross sections are described and diagrammed. Detailed analysis shows that when mathematical models are used and reflected wave materials carefully processed a differentiated cross section can be obtained of the complex block structure of the oceanic crust, emphasizing individual structural forms. It was found that the anomalous thickness of the crust on the two elevations, up to 15 km and more, results from thickening of all layers of the crust, the greatest increase resulting from expansion of layers II and III of the crust by the appearance of new strata with intermediate wave transmission velocities. Continuous tracking of deep boundaries shows the seam nature of the joint between the deep water Pacific trenches and the Shatskiy and Hess elevations, with the formation of compensation folds where they join. Figures 3; references 25: 23 Russian, 2 Western.

[199-6508]

# ONE PECULARITY OF GENERATION OF ROSSBY WAVES IN STRATIFIED OCEAN

Moscow OKEANOLOGIYA in Russian Vol 23, No 3, May-Jun 83 (manuscript received 9 Apr 82; after revision 23 Aug 82) pp 373-381

RESNIK, G. M., Institute of Oceanography imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] This work studies the linear quasigeostrophic response of a continuously stratified ocean to a random atmospheric effect. Turbulent exchange of momentum, heat and salt are considered, allowing determination not only of the energy flux from the atmosphere to the ocean, but also the energy of oceanic movements, the relationship between energies of barotropic and baroclinic modes. One peculiarity of atmospheric generation of quasigeostrophic movements in a baroclinic ocean is that the energy capacity of

the ocean depends essentially on the relationship of turbulent transfer of momentum and density diffusion and increases with a decrease in density diffusion. References 9: 4 Russian, 5 Western.  
[179-6508]

UDC 551.465.5

#### SYNOPTIC NUMERICAL PREDICTION OF CURRENTS IN POLYMODE AREA

Moscow OKEANOLOGIYA in Russian Vol 23, No 3, May-Jun 83 (manuscript received 21 Dec 81; after revision 21 Apr 82) pp 382-389

SEIDOV, D. G., Institute of Oceanography imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] A study is made of the flow of a rectangular area of the ocean with a smooth bottom on the beta plane with open lateral boundaries. Using well-known equations for the balance of momentum, heat and salts and assuming conditions of incompressibility and hydrostatics as well as linear variation of density as a function of temperature and salinity, the balance equations are derived. The synoptic prediction model which results was used to predict flow fields and density in the polymode test area. Sample calculations are presented in which the initial field of density was the field observed during the 26th voyage of the research vessel "Akademik Kurchatov" as a part of the Polymode program in February-May 1978. Five synoptic surveys were made in all utilizing 25 to 35 stations at the intersections of a rectangular grid with a spacing of 34 nautical miles. The center of the test area was at 29°N, 70°W. The prediction in the model was based on hydrologic observations at the initial moment of calculation alone. The comparison of predicted results and measured results prompts the author to consider the experience of synoptic numerical prediction of ocean currents "positive". Figures 3; references 11: 8 Russian, 3 Western.  
[179-6508]

UDC 551.465.7

#### EXPERIMENTS ON MODELING OF SELF-OSCILLATIONS RESULTING FROM INTERACTION OF OCEAN AND ATMOSPHERE

Moscow OKEANOLOGIYA in Russian Vol 23, No 3, May-Jun 83 (manuscript received 22 Feb 82; after revision 22 Jul 82) pp 399-405

DARICHEVA, L. V. and CHUPRYNIN, V. I., Far Eastern State University, Vladivostok; Pacific Ocean Institute of Geography, Far Eastern Scientific Center, USSR Academy of Sciences, Vladivostok

[Abstract] An earlier work, based on analysis of multiannual series of hydro-meteorological observations in the North Atlantic, formulated a hypothesis of the development of self-oscillations during large scale thermodynamic

interactions between the ocean and the atmosphere. The hypothesis presumes the presence of large-scale oceanic water circulation, which was modeled in ring-shaped and cylindrical vessels. The next step in the improvement of the model is inclusion of two interacting circulations simulating cyclone-anticyclone systems in the Atlantic or Pacific, separated by a frontal zone. This work presents results of experiments performed in a laboratory installation for this purpose. The installation is diagrammed and water currents at various depths in the figure-8 shaped installation with two motor-driven propellor-type circulators are diagrammed. In the experimental data due to the feedback which considers both nonlinearity and interaction of the circulations, oscillations are synchronized and oscillations of a single period develop. This agrees completely with the results of the mathematical model. At low mean speeds, in addition to the physical mechanisms for development of oscillations discussed in this article, another may arise, related to movement of water along vertical and horizontal paths. Figures 4; references 13: (Russian).  
[179-6508]

UDC 551.465.5(265)

#### EQUATORIAL CURRENTS IN PACIFIC OCEAN AT MERIDIAN 180°

Moscow OKEANOLOGIYA in Russian Vol 23, No 3, May-Jun 83 (manuscript received 16 Mar 82) pp 414-419

BUBNOV, V. A. and YEGORIKHIN, V. D., Atlantic Division Institute of Oceanography imeni P. P. Shirshov, USSR Academy of Sciences, Kaliningrad

[Abstract] In October-November 1981 during the 27th voyage of the "Dmitriy Mendeleev" five independent buoy stations were set out along the 180° meridian at 1°40'N, 0°40'N, 0°0', 0°40'S and 1°40'S. Each buoy had 10 to 12 instruments placed in the top 1000-meter water layer in accordance with the expected vertical current structure. Measurements were also performed from the "girlyanda" drift station. Shifting of the instruments from the drift station over depth on 14 November 1981 produced a detailed profile of the equatorial current in the top 700-meter layer. The drift of the ship was determined relative to the buoys by the use of the ship's radar and the MAGNAVOX satellite navigation system. The results of all these measurements present a general picture of the structure of the velocity and thermohaline fields in the vicinity of the equator. It is concluded that the meanders in the Cromwell current are Kelvin waves propagating to the east, arising at the east coast of Australia under the influence of disturbances in the trade circulation of the southern hemisphere and are trapped by the equatorial waveguide as they move to the north. Figures 4; references 10: 7 Russian, 3 Western.  
[179-6508]

# DIAGNOSTIC CALCULATIONS OF WATER CIRCULATION IN THE AUSTRALIA-NEW ZEALAND SECTOR OF ANTARCTIC OCEAN BASED ON POLEX-SOUTH-81 EXPEDITION

Moscow OKEANOLOGIYA in Russian Vol 23, No 3, May-Jun 83 (manuscript received 10 Nov 81; after revision 4 Aug 82) pp 433-438

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[Abstract] Circulation in the Australia-New Zealand sector of the ocean has not previously been studied in detail. Calculation of three-dimensional circulation in this little-studied region of the ocean based on fields of temperature and salinity obtained as a result of oceanographic surveys are therefore of interest. Such a survey was performed for the first time as a part of the Polex expedition in January-February 1981 by the "Professor Vize", "Professor Zubov", "Priliv" and "Volna". The stations were set out on a grid with latitude and longitude steps of 1 and 2.5°, respectively. Measurements were performed at standard levels to the bottom. Diagrams of summary current velocities and vertical circulation are presented for the surface, 50, 1000 and 3000 m levels. The circulation in this region of the ocean is complex in its structure, the major element of the upper kilometer layer being the Antarctic circumpolar current, beneath which meridional currents and vortex formations predominate. Figures 2; references 13: 10 Russian, 3 Western. [179-6508]

UDC 551.465

## MEDIUM SCALE-VORTICES IN OCEAN AND THEIR GEOGRAPHIC PROPAGATION

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian No 4, Jul-Aug 83 (manuscript received 8 Jul 82) pp 28-36

BLATOV, A. S., IVANOV, V. A., KOSAREV, A. N. and TUZHILKIN, V. S.

[Abstract] Oceanographic research with modern equipment including satellites and floating buoys has lead to one of the greatest oceanographic discoveries of the history of this science, medium-scale (days to months) variability of oceanographic conditions, what can truly be called the "weather" of the ocean, frequently extending clear to the bottom. As in the atmosphere, weather in the ocean is determined primarily by medium-scale vortex formations, oceanic cyclones and anticyclones. Their difference from their atmospheric analogues is primarily their horizontal dimensions (up to 100 km in the ocean, 100 to 1000 km in the atmosphere), the speeds of movement of the vortices (up to 10 km/day) and of orbital movements within them (about  $10^{-1}$  m/s), as well as the characteristic thermodynamic structures such as temperature fields, etc. These differences are basically related to the difference in densities of the two media and the conditions of their density stratification. This article summarizes published results of Soviet and

western studies of oceanic mesovortex formations in order to begin their systematization and analyze their geographic distribution in the ocean. A regional genetic principle was used to systematize oceanic mesovortex formations. A world map of the distribution of various types of mesovortex formations in the ocean is presented, based on 1981 data. Most of the types of mesovortex formations mentioned in the study have now been mathematically modeled both analytically and numerically, though only partial success has been achieved in the description of individual features of the structure and dynamics of these vortices. Figures 2; references 22: 9 Russian, 13 Western. [188-6508]



TWO TYPES OF QUIET IN SEISMOACOUSTIC PREDICTION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 1, May 83  
(manuscript received 29 Dec 82) pp 68-71

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[Abstract] Laboratory studies of acoustic emission during the destruction of rock samples and observations of seismoacoustic emission in mine shafts have revealed the acoustic quiet effect. The slow loading of a rock sample is accompanied by an increase in the intensity of acoustic emission, the intensity passes through a maximum and prior to a new sharp increase in intensity no acoustic pulses are observed. Applicable to the prediction of earthquakes the seismoacoustic quiet (brief decrease in seismic activity directly prior to the main rupturing) has been observed directly prior to large and moderate earthquakes, making it possible to use this phenomenon as an indicator of onset of a seismically dangerous situation. In this article an attempt is made to formulate a model of formation of the intensity of acoustic emission in different stages of the process of earthquakes preparation. Some semi-quantitative characteristics of seismoacoustic emission are obtained by using qualitative models. The phenomenon of seismoacoustic quiet is examined, in particular, in relation to a model published by I. L. Gufel'd, et al., DAN, Vol 260, No 1, 1981). This is followed by a discussion of laboratory investigations, usually involving destruction of small volumes of material under great loads; the destruction of large volumes of material under small loads is also examined. Also considered is the Lifshits-Slezov coalescence theory (ZhETF, Vol 35, No 2, 1958), which is related to pore size and total number of pores in a volume, which helps to explain the seismoacoustic quiet phenomenon. References 15: 14 Russian, 1 Western.  
[152-5303]

GEOMAGNETIC FIELD CHANGES ASSOCIATED WITH SEISMIC ACTIVITY IN TASHKENT  
GEODYNAMIC POLYGON

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 1, May 83  
(manuscript received 15 Jan 82) pp 72-74

MAVLYANOV, G. A., academician, Uzbek SSR, TSVETKOV, Yu. P., BERDALIYEV, Ye.  
and ABDULLABEKOV, K. N.

[Abstract] Investigations of the seismomagnetic effect in the Tashkent geodynamic polygon have provided a realistic basis for predicting earthquakes on the basis of geomagnetic precursors. Almost all earthquakes with  $M > 4$  in this polygon have been accompanied by local changes in the geomagnetic field. Attempts have been made to study the dynamics of the geomagnetic field in epicentral zones after the main event, but these have been too brief (10-20 days) to provide information on further processes at earthquake foci. Accordingly, the authors investigated the dynamics of the geomagnetic field in the epicentral zone of a recently transpiring earthquake over a period of more than 15 months. This earthquake occurred on 11 December 1980 (magnitude 5.5, focal depth 10-15 km). The following day systematic magnetic measurements were initiated to determine the modulus of the total vector  $T$ . Field proton stations were placed at points I and II in the epicentral zone, the useful signal being the increments of the field difference  $\Delta T$  obtained by synchronous measurements at the remote and investigated points. A figure shows the  $\Delta T$  magnetic field changes at these two stations with 10-day and 30-day averaging of the mean daily  $\Delta T$  values. At station I there was a slow decrease of the geomagnetic field manifested synchronously with attenuation of the seismic reg-me at the focus. There was a correlation between the released seismic energy and local changes of the geomagnetic field, evidence of the existence of a dependence between these processes. Field changes at point II had a sign opposite of point I. This and other facts gives basis for hoping that it is possible to check the further development of the seismotectonic process at an earthquake focus on the basis of data on local changes of the geomagnetic field. Further, these local field changes may make it possible to give an intermediate-range prediction of earthquakes with  $M > 5$  in this polygon. Figures 2; references: 6 Russian.

[152-5303]

## INTERRELATIONSHIP OF EARTHQUAKE MAGNITUDE AND THERMODYNAMIC PARAMETERS IN FOCAL REGION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 270, No 1, May 83  
(manuscript received 14 Jan 83) pp 74-77

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Academy of Sciences, Moscow

[Abstract] According to theoretical studies, an interrelationship between the thermodynamic parameters of the lithosphere and asthenosphere can be postulated from the very nature of the process of accumulation of thermoelastic stresses in the earth's upper shell as a result of the nonuniform distribution of temperatures and the difference in the physical properties of these shells. The lithosphere and asthenosphere must be regarded as rheological concepts, the first being a colder layer with an increased viscosity and a high concentration of additional stresses and the second as a strongly heated layer with reduced viscosity and sharply reduced release of seismic energy. In accordance with these theoretical concepts, an attempt was made to analyze data on earthquakes for such seismically active orogens as the Caucasus, Tien Shan and Japanese islands. These data made it possible to compute the thermodynamic parameters of the lithosphere and asthenosphere in a logical sequence:

$$\lg E \rightarrow T(K) \rightarrow a_v \rightarrow \epsilon \rightarrow G \rightarrow \sigma \rightarrow \tau_{crit} \text{ and } \lg \eta .$$

Formulas are derived for determining each of these parameters:  $\lg E$  -- logarithm of mean energy of seismic waves;  $T(K)$  -- deep distribution of temperatures (for depths to 100 km);  $a_v$  -- mean value of coefficient of thermal volumetric expansion of focal material up to moment of discharge of additional stresses;  $\epsilon$  -- deformation of volume;  $G$  -- volumetric modulus of elasticity;  $\sigma$  -- normal component of effective stresses of focal region material;  $\tau_{crit}$  -- critical values of shearing component of effective stresses;  $\lg \eta$  -- logarithm of viscosity of material at the depth of distribution of hypocenters. The graphically presented results constitute a family of curves revealing the inverse relationships among the parameters  $T$ ,  $a_v$ ,  $\epsilon$ ,  $\sigma$ , on the one hand, and  $M$ ,  $E$ ,  $\eta$ ,  $G$ ,  $\tau_{crit}$  on the other. All the computed thermodynamic parameters and the corresponding magnitudes can be broken down into two groups. All the parameters of both defined groups are characteristic only for seismically active orogenic regions with a thickness of the lithosphere reduced to less than 35 km and volcanic activity in the neotectonic stage. In other types of regions, especially platforms, the values of these parameters may be different, depending on the factors responsible for the decrease in rock viscosity. Figures 1; references 7: 4 Russian, 3 Western.  
[152-5303]

## SOME RESULTS OF CONTINUOUS TWO-FREQUENCY SEISMOACOUSTIC PROFILING

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA in Russian No 5, May 83 pp 143-146

VASIL'KOV, V. A., GRIGOR'YEV, V. V., LYAKHOV, L. L. and NESMELOVA, N. M., Moscow Geological Prospecting Institute imeni S. Ordzhonikidze

[Abstract] Seismoacoustic profiling is highly important for studying the shelf: tracing relief of the sea floor and bedrock basement and determining thickness of the sedimentary layer and its structure, as well as detecting folds and faults, as well as other structures. Simultaneous observations in several frequency ranges are particularly effective. The Moscow Geological Prospecting Institute has developed apparatus for two-channel observations by the continuous seismoacoustic profiling method. A block diagram in the article shows the presence of two channels: 100-1500 Hz and 500-3000 Hz. Observations in the higher frequency range are for increasing the clarity and detail of tracing of sea floor morphology and enhancing resolution of the upper part of the section; observations in the low frequency range increase the total effective depth of the investigations. Comparison of differences in absorption at different frequencies increases reliability in evaluation of lithological characteristics and features of individual layers of the section. The frequency separation is achieved by a special excitation block with two independent electrosparc sensors. The receiving-recording block consists of two independent reception channels with a set of filters combined into a common two-channel recorder. The recorder ensures a scanning rate of 120 msec for the HF channel and 240 msec for the LF channel. The effective depth is up to 300 m or more for the LF channel and up to 180 m or more in the HF channel. The outfit is intended for two-frequency observations from abroad a single vessel. Experience with two-channel profiling has shown that although the records at different frequencies are identical they differ in clarity, each containing information supplementing the other; reliability and quality of the collected information are improved. Figures 3.

[164-5303]

UDC 550.343.6:538.3

## GENERATION OF ELECTROMAGNETIC RADIATION UPON OSCILLATION OF DOUBLE ELECTRIC LAYERS AND ITS MANIFESTATION IN EARTHQUAKES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 1, Jul 83  
(manuscript received 17 Feb 83) pp 80-83

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[Abstract] An estimate is made of the intensity of electromagnetic radiation upon oscillating compression of double layers such as the layers at the boundaries of grains of solids and electrolytes including films of water and areas of

contact potential difference between the boundaries of solid bodies as might occur during earthquakes. It is found that this previously uninvestigated effect might make a significant contribution to the intensity of the electromagnetic radiation observed during earthquakes. Figure 1; references 9 (Russian). [197-6508]

UDC 551.521

SPECIFICS OF TIME COURSE OF RADON CONTENT IN SUBSOIL ATMOSPHERE IN SEISMICALLY ACTIVE ZONES OF WESTERN FERGANA BEFORE EARTHQUAKES OF 18 OCTOBER and 11 DECEMBER 1980

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 1, Jul 83  
(manuscript received 26 Jan 83) pp 72-75

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Moscow

[Abstract] Apparently fluids rising from the depth in the aqueous medium filling the space between discrete fragments of the earth's crust and washing past their emanating surfaces on the way up carry the nuclei of the short-lived radioactive isotope  $^{222}\text{Rn}$  into the atmosphere in quantities significantly greater than the background level. This is an important factor allowing an approach to the explanation of the nature of the repeatedly observed radon anomalies in spring water and in the subsoil atmosphere. Therefore the structure of the  $^{222}\text{Rn}$  flow in the seismically active zones of western Fergana around the two earthquakes mentioned in the title is of interest. Several phases are observed. They are explained by a geological interpretation of the multistaged jointing of rock and decay of radon. The radon concentration rise rate increases with the approach of a seismic event. The seismic event usually happens after the radon concentration reaches its maximum and begins to decrease. Figures 2; references 15: 13 Russian, 2 Western. [197-6508]

UDC 550.834.05

EFFECTIVENESS OF SEISMIC METHODS IN THE SEARCH FOR NONANTICLINAL OIL AND GAS TRAPS IN SOUTHEAST OF NORTHERN SAKHALIN

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 3, May-Jun 83  
(manuscript received 15 Dec 82) pp 94-96

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[Abstract] The oil-bearing Neogene section of northern Sakhalin is made up of thin sand, clay and silt masses with characteristic local changes in thickness and lithology. The use of interference systems for reception and high

multiplicity profile processing of reflected waves allows complex geological problems to be solved in this area. Summation of repeated observations levels the influence of surface conditions and local changes in reflecting properties of individual layers. The correlation method of reflected waves, based on first arrivals, reveals no refracting horizons. The production of stable reflected waves and the universal drop in electrical resistance indicate that the sandy top of the Daginsk horizon is an extended refracting boundary, indicating that the correlation refracted wave method could be used to map the roof of the oil-bearing Daginsk deposits. The reflected wave method, using multiple observations, is found to be the only geophysical method capable of supporting the search for nonanticlinal oil and gas traps. Figures 2; references 2 (Russian).  
[200-6508]

UDC 550.834.053

#### CHANGE IN SEISMIC VELOCITIES IN NORTHERN SAKHALIN

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 3, May-Jun 83  
(manuscript received 1 Jun 82) pp 91-93

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[Abstract] Difficulties in studying elastic wave velocities in northern Sakhalin result from their great variability with area, a result of the complex seismogeological conditions of the territory. An earlier work showed that in northern Sakhalin a linear rule of increase in the interval velocity with depth can be approximately noted. This article presents a more detailed analysis of the nature of change of the interval velocity over the territory of northern Sakhalin and estimates the influence of depth on its value. It is found that the vertical velocity gradients change within broader limits than was previously thought. Generalized characteristics of the influence of depth on P-wave velocity are determined. The ability to produce velocity anomalies from rocks of different ages decreases with depth. The need is shown to consider geostatic pressure in determining the amplitude of tectonic disruptions by interval velocities. An analytic solution of this problem is presented for linear variation of velocity with depth. Figures 3; references 5 (Russian).  
[200-6508]

## GEOELECTRIC CROSS SECTION OF SOUTHERN PRIMOR'YE BASED ON MAGNETOTELLURIC SOUNDINGS

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 3, May-Jun 83  
(manuscript received 12 Jul 82) pp 88-90

STARZHINSKIY, S. S., Pacific Ocean Institute, Far Eastern Scientific Center,  
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[Abstract] In 1975-1976, magnetotelluric soundings were performed at three points in Primorskiy Kray. Magnetotelluric fields were recorded with GG-42 magnetic variation stations using 500-m and 300-m receiving lines. The two 500-m lines were oriented on azimuth  $0^\circ$ , the 300-m line on azimuth  $30^\circ$  to the northeast, parallel to the shore. Field observations were processed by computer according to a program which is briefly described. Magnetic field polarization at all points varied broadly from quasilinear to elliptical and near-circular. A conducting layer was found to be present at about 30-32 km depth. This apparently corresponds to a layer of reduced seismic velocities at the base of the earth's crust at a depth of about 30 km located by deep seismic soundings. This correlation between layers with low electrical resistance and low seismic wave velocities within the earth's crust is seen in other regions as well. Figures 2; references 10: 8 Russian, 2 Western.  
[200-6508]

UDC 551.35(265.53)

## BOTTOM STRUCTURE OF NORTHWESTERN PORTION OF SEA OF OKHOTSK

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 3, May-Jun 83  
(manuscript received 2 Jul 82) pp 35-38

ANDREYEV, A. A., KRASNYY, M. L., SAPOZHNIKOV, B. G., SNEGOVSKIY, S. S. and  
KHVEDCHUK, I. I., Sakhalin Combined Scientific Research Institute, Far  
Eastern Scientific Center, USSR Academy of Sciences

[Abstract] In 1980 combined geophysical studies were performed on the research vessel "Morskoy Geofizik" including gravimetry, magnetometry, echo soundings and high-frequency seismic profiling by the central beam method with the maximum of the recorded spectrum at 200 Hz. The gravitational field of the area featured primarily a northeastern strike of anomalies. The gravitational data were used to estimate the thickness of the sedimentary mass. A structural diagram of the southwestern Sea of Okhotsk is presented, as well as cross sections of geophysical profiles. The results indicate that no structural directions except for the strike of reef-forming structures mentioned appear directly on the underwater continuations of the seam zones separating the tectonic blocks of the continental Far East. Figures 2; references 8 (Russian).  
[200-6508]

## ACOUSTICAL PRECURSORS AND FRACTURE KINETICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 5, May 83  
(manuscript received 13 Apr 81) pp 104-108

MUKHAMEDOV, V. A., Turkmen Academy of Sciences, Institute of Physics and Technology

[Abstract] An attempt is made to describe two types of acoustical precursors from the standpoint of a previously suggested model of a fracture. An expanded description of the fracture model is presented, with conclusions concerning the nature of acoustical emission, and propagation of sound in a medium before fracture is studied. The fracture model, which presumes that the process of fracture is independent of the details of interaction of neighboring elements of the medium, but is determined primarily by large-scale fluctuations in medium parameters, allows the theory of percolation of random nodes to be used to produce a description of the characteristic properties of certain fracture precursors such as an increase in the number of acoustical emission pulses, decrease in the slope of the curve of their repetition and reduction in the velocity and increase in the absorption factor of sound waves in experiments involving transmission of sound through the fracture focus. Figures 2; references 17: 13 Russian, 4 Western.  
[195-6508]

UDC 550.341.5

## COMPARATIVE DESCRIPTION OF GROUNDWATER FLOW AND LEVEL REACTION BEFORE EARTHQUAKES

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 5, May 83  
(manuscript received 25 Dec 81) pp 100-103

MONAKHOV, F. I., deceased, KHANTAYEV, A. M., KECHAYKINA, V. S. and SHISHKIN, A. A., USSR Academy of Sciences, Far Eastern Scientific Center, Sakhalin Combined Scientific Research Institute

[Abstract] The reaction of the groundwater level before an earthquake was studied in long-term continuous observations in the Kuril-Sakhalin area. The following was observed: several days before an earthquake the water level in wells drops by 3 to 10 cm, then rises to its initial value. The earthquake occurs primarily at the beginning of the rise. The nature of water fluctuations is the same before earthquakes at all depths and of all types. The water level is influenced strongly by changes in atmospheric pressure and rain, which can change the water level by 30 to 50 cm. The sensitivity of water level decreases with increasing distance from the epicenter. Observational materials on the flow rate of water and gas in wells indicate that flow rates increase sharply within 10 days before an earthquake with  $M=4-7$ .



Flow rates increased sharply then decreased to normal in association with 20 earthquakes studied. The flow rates increase at the same time water levels in the wells decrease. The change in flow rate is much greater than the change in water level, and is not sensitive to atmospheric pressure or precipitation. Flow rate is therefore probably a better earthquake predictor than water level. Figures 2; references 4 (Russian).  
[195-6508]

UDC 550.341.2

#### MODELING AND PREDICTING OF FRACTURE BY PERCOLATION THEORY

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 5, May 83  
(manuscript received 21 Dec 81) pp 24-34

CHELIDZE, T. L. and KOLESNIKOV, Yu. M., Institute of Geophysics, Georgian Academy of Sciences

[Abstract] Methods of percolation theory are used to analyze the problems of establishment of the nature of changes in physical properties of matter in various stages of fracture and analysis of their prognostic significance, the search for analogs of fracture criteria in percolation theory, modeling of the influence of clustering of fractures on the distribution of amplitudes of acoustical pulses, and construction of simple cyclical and anisotropic models of fracture considering the finite nature of the systems involved. Comparison of the basic statements of percolation theory with experimental facts accumulated in fracture physics leads to the conclusion that it is possible to create a percolation model of fracture. This model can describe fracture regardless of its scale as a developing evolutionary process, modeling the nature of changes in structure-sensitive physical properties of matter and acoustical conditions in various stages of this process and predicting the probability of appearance of a major fault based on the number of elementary events or more precisely their distribution density, the dimensionality and the dimensions of the system, configuration of the network of fractures and other factors. The flexibility and variety of percolation models allow them to be developed as applicable to most known types of fracture. Figures 4; references 21: 9 Russian, 12 Western.  
[195-6508]

# DENSITY HETEROGENEITIES IN THE MANTLE BASED ON DATA ON DEPTH TO ITS FREE SURFACE. CONTINENTAL REGIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 5, May 83  
(manuscript received 28 May 82) pp 3-11

ARTEM'EV, M. Ye., KABAN, M. K. and CHESNOKOV, Ye. M., USSR Academy of Sciences, Institute of Earth Physics imeni O. Yu. Shmidt; USSR Ministry of Geology, Neftegeofizika Scientific and Production Association

[Abstract] A study is made of the information content of the study of depth to the "free mantle surface" in continental regions, using the territory of the USSR as an example. The reliability of results is determined by the reliability of estimation of the parameter  $h$ , which depends significantly on the error related to determination of rock density from data on seismic wave propagation velocities. The most reliable differences in depth to the free mantle surface are observed between the East European platform and the Turan and West Siberian Paleozoic plates. The differences in the value of  $h$  agree satisfactorily with differences in the time of tectonic stabilization of the regions. They also agree with estimates of the temperature at the Mohorovicic discontinuity. Significant information on the irregularities of the upper mantle can be obtained by comparatively simple additional analysis of results already available from the study of the structure of the crust by deep seismic soundings. The method suggested, the effectiveness of which is illustrated for both oceanic and continental regions, is simple while highly informative at least at the qualitative level. Its practical application and further development will allow effective extraction of useful information from the results of expensive geophysical experiments. Figures 4; references 6 (Russian).  
[195-6508]

UDC 681.3.06:550.831/.838

# SOLUTION OF DIRECT GRAVIMETRY AND MAGNETOMETRY PROBLEMS IN RELATION TO MODELING OF COMPLEX GEOLOGICAL MEDIA

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 6, Jun 83 (manuscript received 6 Sep 82) pp 116-128

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[Abstract] A table is presented of the types of direct problems commonly solved by computers in the modeling process. They include both problems related to the cross sections of and surfaces of bodies. A method of improving the economy of solution of direct problems is suggested, based on approximating the vertical parallelepipeds which are the elements of the approximating structure as infinitely thin bent filaments, their form or density depending

on the mutual positioning of points. The best forms of representation of information on the geometry of complex geological models are cross sections and hypsometric points on the surfaces of bodies arranged in a uniform grid. When sufficiently detailed modeling is performed in mining areas, corrections for topographic masses are unnecessary, since they are recalculated in the internal zone considering the specific data available on variations in rock density. Figures 2; references 22: 20 Russian, 2 Western.  
[196-6508]

UDC 551.242.2(265)

#### GENERAL FEATURES OF PACIFIC OCEAN BED GEODYNAMICS

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 6, Jan 83 (manuscript received 30 Apr 82) pp 24-32

YEGIAZAROV, B. Kh. and LITVINOV, E. M., Sevmorgeologiya, Leningrad

[Abstract] Some of the specific features of the geologic structure and physical fields of the Pacific Ocean reflecting the most important processes and phenomena in the development of this portion of the planet are noted. The primary stages in the development of trinary rift joints in the Mesozoic and Cenozoic development of the Pacific Ocean floor are traced. Five stages in the development of the Pacific Ocean rift systems are outlined. The general elements of the Pacific geostructure including the continental border, active transition zones, mid-ocean ridges and large volcanic upthrusts can all be interpreted on the basis of the specifics of rift formation. The development of the greatest megastructures of the Pacific Ocean and their spatial positions indicate migration of processes of rift formation in two opposite directions. Figures 6; references 10: 6 Russian, 4 Western.  
[196-6508]

UDC 553.98.041.(477)

#### OIL AND GAS GEOLOGICAL REGIONALIZATION AND PROSPECTS FOR OIL AND GAS CONTENT OF UKRAINE

Kiev GEOLOGICHESKIY ZHURNAL in Russian Vol 43, No 4, Jul-Aug 83 (manuscript received 5 Sep 82) pp 1-14

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[Abstract] Oil and gas geologic regionalization of the Ukraine is performed, distinguishing provinces, areas and zones of oil and gas accumulation. The basis of the regionalization is the regularities of location of hydrocarbon deposits, the history of geological development of the regions, conditions of formation of sedimentary masses, specifics of the structure of the basement, hydrogeological, geochemical and other criteria of oil and gas content,

which significantly influence processes of generation and accumulation of hydrocarbons, with the tectonic factor the most important. Each of the provinces distinguished is briefly described and the locations of oil and gas deposits in several provinces are mapped. The prospects for oil and gas in each province are estimated. Figures 3; references 16 (Russian).  
[201-6508]

UDC 525.14:550.383:553.981/.982

CHARACTERISTICS RELATING OIL AND GAS CONTENT OF CRUST WITH SURFACE SHAPE OF GEOID AND GEOMAGNETIC FIELD

Kiev GEOLOGICHESKIY ZHURNAL in Russian Vol 43, No 4, Jul-Aug 83  
(manuscript received 11 Sep 81) pp 14-22

SHTENGELOV, Ye. S., Odessa State University

[Abstract] Data are presented confirming the assumption that the shape of the geoid is related to manifestations of contemporary geotectonic activity. Considering the relationship of the processes of formation of hydrocarbon deposits with the tectonic development and structural conditions in the crust, a comparison is presented of the location of large oil and gas deposits with the shape of the surface of the geoid. Most such deposits are found to be located on the outskirts of depressions in the geoid, areas where its surface is below the surface of a geodesic ellipsoid. In such areas as Europe, where the overall altitude of the surface is higher than the geodesic ellipsoid, areas with oil and gas deposits are generally in areas of local depressions within the overall elevation. Furthermore, most of the large deposits of oil and gas in the world are located in areas where the geomagnetic field intensity is 0.4 to 0.6 oe. Figures 3; references 14: 13 Russian, 1 Western.  
[201-6508]

UDC 550.834

OPTIMAL LINEAR PHASE CORRECTING FILTRATION AS MEANS FOR INCREASING RESOLUTION OF SEISMIC RECORD

Kiev GEOFIZICHESKIY ZHURNAL in Russian Vol 5, No 4, Jul-Aug 83  
(manuscript received 16 Jan 82) pp 43-50

TYAPKIN, Yu. K. and NAUKO, G. G., "Ukrgeofizika" Geophysical Observatory, Kiev

[Abstract] A new algorithm is suggested for increasing the resolution of seismic recording, using a general model of the phase spectrum of an elementary signal in its operating frequency band. It is an optimal version of band filtration and can be used independently, and also in combination with minimum phase deconvolution. A comparison is presented of the results of optimal

linear-phase correcting filtration according to the algorithm presented in the article with ordinary band and band correcting filtration after minimal phase deconvolution. The essence of the algorithm is adjustment of the amplitude spectrum of the signal to the optimal form found by means of variational methods, minimizing the signal plus envelope length measure selected. The advantage of the algorithm is that there is no need to use information on the phase spectrum of the signal. Figure 1; references 16: 10 Russian, 6 Western.  
[202-6508]

UDC 550.838(571.1)

# RESULTS OF SCALING OF ANOMALOUS MAGNETIC FIELD INTO LOWER HALF-SPACE ON SOUTHERN MARGIN OF WEST SIBERIAN PLATFORM

Novosibirsk GEOLOGIYA I GEOfIZIKA in Russian No 4, Apr 83 (manuscript received 9 Apr 82) pp 86-91

ZAKHAROVA, T. L. and SHARLOVSKAYA, L. A., Institute of Geology and Geophysics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] The problem of regionalization of an area on the basis of the degree of magnetic activity of rocks at a depth of 8 km and the discrimination of metallogenetic zones associated with alkaline magmatic complexes has been solved for the northeastern part of the Kokchetavskiy anticlinorium and the northern part of the Vostochno-Kokchetavskiy synclinorium (southern margin of West Siberian Platform). In the transformation of the observed field  $\Delta T_a$  use was made of the B. P. Vatlin method. The investigated region has a prolonged history of geological development and is a region of Late Caledonian folding. The general background of the observed magnetic field over the investigated region is slightly negative, fully corresponding to a high degree of saturation of the upper part of the crust with rocks of granitoid composition. Ophiolitic zones correspond to strong linear anomalies controlling the occurrence of ultrabasic intrusions. Crustal sectors within which deuterorogenic magmatic complexes have developed are characterized by specific anomalous zones where local anomalies of different orientation are concentrated, complicated by secondary maxima. Two specific zones are situated to the southwest and southeast of Kokchetav. The transformed magnetic field, transformed into the lower half-space, is shown in Fig. 1, a map showing new information on the distribution of magnetically active masses at a depth of 8 km. On the basis of the degree of concentration of alkaline magnetically active rocks within the confines of this region it was possible to discriminate smaller crustal blocks with characteristic metallogenetic profiles. Six blocks were defined and described, of which blocks I and V are of the greatest importance in metallogenetic respects (Fig. 2 shows a map of these two blocks at an enlarged scale.) This transformation of the anomalous magnetic field into the lower half-space made it possible to obtain a clearer idea concerning the nature of the Hercynian activation, casting light on the presence or absence of alkaline magmatic complexes. Figures 2; references: 11 Russian.  
[153-5303]

## EARTH CORE MODEL AND GEOMAGNETIC FIELD

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 5, May 83 (manuscript received 26 Jul 82) pp 78-84

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[Abstract] An attempt is made to develop a hypothesis of a "hot" earth, assuming that a dust-gas cloud existed at the location of the earth four and one-half billion years ago, primarily consisting of oxygen and silicon. According to the model the activation of the tectonic life of the planet resulted from decompression of matter which was in a supercompressed state after the earth was formed from the cloud. The earth after the cloud compacted would have had a diameter of about half that of the present earth, its mean density about 50 g/cm<sup>3</sup>. The processes occurring according to this model at the boundary layer between the solid inner core and the outer liquid core are analyzed. The model indicates there should be a correlation between the expansion of the earth and the polarity of the magnetic field. The contemporary magnetic field polarity corresponds to its minimum tectonic activity. The model of the core of the earth and its magnetic field attempts to show that the source of internal energy, its expansion, continental drift, the magnetic field, its inversion and correlation with active tectonic processes are a result of the process of condensation of a supercompressed, superheated substance. This model is qualitative in nature but could serve as a basis for more detailed studies of the basic physical regularities of the phenomena and for the development of experiments to test the model. References 10 (Russian). [185-6508]

UDC 550.831.016

## CALCULATION OF EARTH SURFACE DEFORMATIONS BASED ON GRAVITATIONAL DATA

Novosibirsk GEOLOGIYA I GEOFIZIKA in Russian No 5, May 83 (manuscript received 18 Nov 81) pp 85-89

MASLOV, L. A., Institute of Tectonics and Geophysics, Far Eastern Scientific Center, USSR Academy of Sciences, Khabarovsk

[Abstract] The influence of the relief of the surface of a fluid and density anomalies caused by temperature variations on the external gravitational field generated by the fluid is demonstrated. The analysis is based on solution of the direct problems of convection. The method used can be described as an inverse problem in geomechanics. A known gravity force field is used to find a certain function defining the mechanical status of a substance. It is considered that the stress in a thin layer of the earth, the lithosphere, is caused by convective currents in the underlying viscous matter. A method is

described for calculating the deformations of the crust on the basis of regional values of the force of gravity for comparatively small areas. This allows the sphericity of the earth to be ignored and the problem to be looked upon as one of deformation of a half-space. References 9: 3 Russian, 6 Western. [185-6508]

UDC (550.831+551.838).052.012

STRUCTURAL-GENETIC ANALYSIS FOR INTERPRETATION OF POTENTIAL GEOPHYSICAL FIELDS FROM THE SYSTEMS APPROACH

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 4: GEOLOGIYA in Russian No 3, May-Jun 83 pp 87-91 (manuscript received 10 Sep 81)

SEMENDUYEV, M. M.

[Abstract] A review is presented of existing methods of interpretation of potential geophysical fields. The concept of the systems approach as a combination of elements in interactions with each other has now been applied to structural and genetic analysis for regionalization of geophysical fields. A geophysical field (gravitational or magnetic) is not looked upon as a random set of individual anomalies, not related to each other and reflecting the presence of isolated perturbing masses, but rather as a system of anomalies in space reflecting the continuous transition of structural and material systems in the crust. The stage of regionalization of geophysical fields is thus an important stage in qualitative interpretation and the regionalization procedure is essentially a systems structural analysis procedure for geophysical fields. Finally, the regionalization of geophysical fields is performed considering a priori tectonic concepts and the data of other geophysical methods. This system of interpretation, called structural-genetic analysis, includes both regionalization of geophysical fields and determination of the geological nature of the elements distinguished. References 15: (Russian). [183-6508]

UDC 550.34.016

STUDY OF SHEAR FRACTURE FORMATION AND SEISMIC CONDITIONS IN SAMPLES CONTAINING LOW STRENGTH INCLUSIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 6, Jun 83 (manuscript received 9 Jun 82) pp 59-73

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[Abstract] Results are presented from experiments on the fracture of pyrophyllite samples containing reduced strength inclusions, which may reflect to some extent the actual situation in an earthquake focus. The experiments

allowed a study of the process of fracture formation from the appearance of fractures in areas of reduced strength to the development of shear macrofissures. The samples were rectangular prisms 10 to 14 cm high with an area of the face to which the uniaxial load was applied of 10 x 4.5 cm. Penetrating apertures 0.25 cm in diameter were drilled through the central part of the large face to create stress concentrators and an area of reduced strength. These holes were left empty or filled with epoxy resin. The shape of the area of reduced strength thus produced was circular, elliptical or rectangular. The experiments clearly showed that the fracture process begins in the area of the reduced strength inclusion containing stress concentrators with the appearance of separation fractures which develop stably, chaotically distributed through the volume of the reduced strength inclusion. Shear fractures are formed at a later stage, developing unstably with stress relief, connecting stress concentrators. Interaction of these fractures leads to the gradual formation of a major shear fracture. The phenomenon of seismic quiet was clearly recorded in a narrow area adjacent to the plane of the major shear fracture before fracture propagation. Its physical mechanism is related to gradual exhausting of unfractured sections in the plane of the major fractures which is forming and the existence of a small remaining barriers. Figures 7; references 30: 12 Russian, 18 Western.  
[182-6508]

UDC 550.34.042.43

# STEADY CORRECTIONS FOR LONGITUDINAL, TRANSVERSE AND SURFACE WAVES IN UNIFORM MAGNITUDE SYSTEM OF EURASIAN CONTINENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 6, Jun 83  
(manuscript received 5 May 81) pp 50-58

VANEK, I., KONDORSKAYA, N. V., KHRISTOSKOV, L., FEDOROVA, I. V., AREF'EVA, L. A., ANTONOV, V. V., VOROB'YEVA, Ye. A., GEVONDYAN, V. B., GOLENETSKAYA, I. G., GRIN, T. P., GUTARKH, B., DARESHKINA, N. M., ZAMANOV, M. YA., ZAKHAROVA, A. I., KAZIN, E. A., LAZAREVA, A. P., MEDVEDEVA, G. YA., MATORINA, T. V., NOVITSKAYA, N. A., OBORINA, S. F., SINEL'NIKOVA, L. G., SITNIKOVA, T. A., SOBOITOVA, V., SOLONTOV, A. P., ULOMOVA, N. V., FABRITSIUS, Z. E., FERCHEV, M. M., TITEL, B., SHATORNAYA, N. V. and SHELTSNER, I.,  
USSR Academy of Sciences; Institute of Earth Physics imeni O. Yu. Shmidt; Siberian Branch, USSR Academy of Sciences; Far Eastern Scientific Center; Geophysics Institute, Bulgarian Academy of Sciences, Sofia; Institute of Earth Physics, East Germany Academy of Sciences; Institute of Geophysics, Polish Academy of Sciences, Institute of Physics, Czechoslovakian Academy of Sciences, Prague; Institute of Geology, Azerbaijan Academy of Sciences; Institute of Seismology, Uzbek Academy of Sciences

[Abstract] A homogeneous magnitude system has been created by the method of successive optimization of station magnitude corrections and calibration functions based on observations at 32 seismic stations spread over the continent of Eurasia. An earlier work presented in detail the basic concepts involved in calculating station magnitude corrections for  $PV$  and  $PV_s$  waves in



the uniform Eurasian magnitude system. This work presents a description of the method and results of computation of station magnitude corrections for PH, SV, SH, LV and LH waves. The base station method is used to compute the corrections. The station correction for the base station is assumed equal to zero. Tables of values of station corrections for the various types of waves are presented for all stations. Analysis of the tabular data shows that the stations react differently to waves of different types and from different regions. For example, there may be positive corrections for P waves and negative corrections for S waves at the same station. None of the standard stations is a station of the first kind for all types of waves. However, general conclusions can be drawn. The greatest number of corrections for all types of waves were obtained for Asia, the least for the Mediterranean area. For PH waves the greatest corrections  $S^m$  were obtained for Siberia and the Far East. Negative corrections were noted primarily in the Caucasus stations. The greatest regional corrections are obtained for earthquakes in Japan. For SV and SH waves the correction picture is quite varied. For LV and LH waves there is a significant increase in the absolute value of station corrections. Surface wave corrections are much more dependent on the region than body wave corrections. Figures 3; references 2 (Russian).  
[182-6508]

UDC 550.341.5

# STUDY OF UNDERGROUND WATER CONDITIONS FOR DETERMINATION OF HYDROGEODYNAMIC EARTHQUAKE PRECURSORS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 6, Jun 83  
(manuscript received 11 May 82) pp 74-86

KISSIN, I. G., BARABANOV, V. L., GRINEVSKIY, A. O., MARKOV, V. M. and KHUDZINSKIY, L. L., USSR Academy of Sciences, Institute of Earth Physics imeni O. Yu. Shmidt

[Abstract] Studies of the hydrogeodynamic precursors of earthquakes were begun in 1980 using the network of observation stations of the Leningrad Earth Physics Institute. A year's cycle of observations yielded new data on the specifics of underground water conditions important for the study of hydrogeodynamic earthquake precursors. The region of the observations is located within the western Fergana depression and surrounding upthrusts. It is a part of the western Fergana artesian basin. The water-bearing horizons are in Quaternary, Neogene-Late Quaternary, Paleogene-Neogene, Mesozoic and Paleozoic deposits. The groundwater is located primarily in alluvial and proluvial formations. The results suggest that properly selected observation stations and parameters can successfully function in areas where anthropogenic influences on the water are strong, such as the oases of Central Asia. Precision measurements of groundwater levels are found to carry a great deal of information, revealing small variations in level including probably precursors of one earthquake. Atmospheric pressure is the primary constant interfering factor hindering determination of short-term hydrogeodynamic precursors.

Near-tidal periodic oscillations in groundwater level were observed, shifting in phase relative to the calculated variations in force of gravity. Further studies will be required under different conditions. Figures 7; references 11: 7 Russian, 4 Western.  
[182-6508]

TRANSPORT OF ADMIXTURES BY EDDY CURRENTS AND STOCHASTIC REDUCTION OF  
METEOROLOGICAL FIELDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 29 Sep 81) pp 532-534

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[Abstract] In an earlier article (IZV. AN SSSR: FAO, Vol 7, No 10, pp 1087-1089, 1971) the author examined the spiraling of admixtures by eddies and later (IZV. AN SSSR: FAO, Vol 12, No 7, pp 755-761, 1976) proposed a method for computing the turbulent propagation of admixtures based on the randomization of the parameters of currents for which a precise Lagrangian description (trajectories of liquid particles) is known. One of the examples analyzed in the second of these papers gave a simple (not containing semiempirical parameters) model of propagation of admixtures in the atmosphere from large sources. In this article it is shown that for broadening the range of applicability of the method of randomization of integrable problems (RIP) it is necessary to find a broader class of eddy currents with a precise Lagrangian description. The class of currents defined in the article as extremely special cases contains the examples analyzed in the two papers mentioned above and this has made it possible to develop models of global propagation of admixtures in the atmosphere. Generalization of the RIP method can be useful in parameterization of the atmosphere and in other fields of theoretical physics. In the RIP method there is a decrease in the number of parameters or "reduction." The procedures for the reduction of meteorological data presented here can be useful for long-range weather forecasting and in prediction of droughts. References: 8 Russian.  
[161-5303]

## MOMENTUM TRANSPORT BY EDDY PERTURBATIONS WITH LOSS OF STABILITY OF PLANE AXIALLY SYMMETRIC SHEAR CURRENT

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian No 5, May 83 (manuscript received 21 May 82) pp 534-539

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[Abstract] In an earlier article (IZV. AN SSSR: MZhG, No 4, pp 27-36, 1981) V. A. Dovzhenko, et al. obtained a quantitative agreement of the theoretical and experimental values of the critical Reynolds number  $Re^*$  at which there is a transition from an aximuthally symmetric flow of fluid to an eddy flow. In the described experiment confirmatin was obtained of the theory of stabilization of the profile of zonal flow after loss of stability of the main azimuthally symmetric flow. The purpose of this new article is to obtain experimental confirmation of the theoretical results obtained earlier within the framework of a three-mode model with few parameters and relating to eddy perturbations and eddy transport of angular momentum. A detailed description of the apparatus used was given in the earlier article, as well as information on the general appearance of the three-eddy flow pattern. In the experiment there was automatic averaging of the velocity field both in time and for different eddies. The laboratory experiments revealed that the observed stabilization of zonal flow with  $Re > Re^*$  ( $Re^*$  is the critical Reynolds number) is ensured by the transport of angular momentum by eddy perturbations whose amplitude is proportional to  $(Re/Re^* - 1)^{1/2}$ . The influence of eddy perturbations on the primary flow can be taken into account by the introduction of the coefficient of "turbulent" viscosity  $K_T$ , as is done in the empirical theory of turbulence, in addition to the kinematic coefficient of molecular viscosity  $\nu$ . An analysis of the stability of shear currents indicated that the defined dependences of the specific geometry of the current (size and shape of current channel, depth of liquid layer), but such current parameters as length of the wave of the most unstable mode, the critical Reynolds number, and the dependence of the coefficient of "turbulent" viscosity  $K_T$  on coordinates are essentially related to current geometry. The materials presented here reveal the good prospects for using laboratory modeling for clarifying the role of shear instability in atmospheric processes. Figures 2, tables 2; references: 9 Russian. [161-5303]

UDC 551.593.52

## OSCILLATORY SPECTRUM OF WATER DIMERS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 5, May 83 (manuscript received 9 Dec 81) pp 542-545

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[Abstract] Investigation of the mechanism of radiation attenuation in the atmospheric transparency window 8-13  $\mu m$  is one of the most pressing problems in

atmospheric optics. In this wavelength range a decisive contribution to radiation absorption is made by water molecules, but the molecular structure of the centers of absorption containing  $H_2O$  molecules has not yet been finally clarified. Different models have been proposed to explain the observed phenomena. This article explores some aspects of the dimer hypothesis, resting on the sum of knowledge concerning the structure and properties of the  $(H_2O)_2$  dimer which has now been accumulated. An attempt is made at representing the absorption spectrum of the water dimer in a broad range of wavelengths, this requiring computation of the frequency of rotational and vibrational-rotational transitions in the dimer molecule and their intensity and insofar as possible, to represent the width of the absorption bands. Particular attention is given to the spectrum of intermolecular oscillations of the water dimer. Neglecting overlapping of the bands, the spectrum consists of three strong lines in the frequency region  $300-600\text{ cm}^{-1}$  corresponding to librational oscillations; the intensity of the translational oscillation is small. Since much remains unclear, a series of recommendations for future research is proposed. Figures 2, tables 3; references 16: 5 Russian, 11 Western.  
[161-5303]

UDC 551.508.91

#### COMBINATION SCATTERING LASER SPECTROMETER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 8 Dec 81, after revision 29 Jun 82)  
pp 546-549

GEORGIYEVSKIY, Yu. S. and KOPEYKIN, V. M., Institute of Atmospheric Physics,  
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[Abstract] The article describes a new laser spectrometer for the combination scattering of light for investigations of the structure of water vapor, trace gases and aerodisperse systems under laboratory conditions and in the real atmosphere. The laser spectrometer includes a double diffraction monochromator, a laser and a registry system based on a photon counter and a gas cell. A block diagram of the apparatus accompanies the text. The ionized argon laser has a power of 4 W in the fundamental lines with wavelengths 4880 and 5145 Å and an angular divergence of about 10 mrad. It is used as a source for excitation of combination scattering in the cell. A special photoelectric digital registry system with a digital printout was developed for the laser spectrometer. The structure and functioning of the apparatus are described in detail. The possibilities of the spectrometer can be judged from the combination scattering spectra of several gases illustrated and discussed in the text. The reliability and excellence of the two-channel recorder with photon counter, efficient digital compensation circuit and the intracavity excitation method clearly have satisfactory parameters for investigating gas admixtures. Figures 2; references 15: 9 Russian, 6 Western.  
[161-5303]

## DYNAMICS OF LOCALIZED VORTICAL PERTURBATIONS--'VORTEX CHARGES' IN BAROCLINIC FLUID

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
No 5, May 83 (manuscript received 14 Jun 82) pp 467-475

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[Abstract] In a quasigeostrophic approximation it is shown that the equation for the evolution of potential vorticity has three-dimensional singular solutions describing "point vortex charges." Equations of motion for such point vortex charges are derived. A variant of the many bodies methods is formulated for the derivation. The parameters characterizing the potential vorticity field are the intensities of the point vortex charges and their coordinates. If this method is used in modeling real geophysical situations the problem arises of determining these parameters on the basis of empirical data. A direct method involves plotting of a map of the potential vorticity field on the basis of barometric maps for several levels and discrimination of regions of localization of the potential vorticity field against the general background and approximation of these regions by a finite number of point vortex charges. No analysis of meteorological maps has yet been made in such a way and this matter is currently being investigated. A question which still remains open is whether localized eddy perturbations close in structure to the described individual point vortex charges are excited in the atmosphere and ocean. It is hoped that the many bodies method will be as effective for the potential vorticity equation as it has been for the vorticity equation in two-dimensional hydrodynamics. References 14: 13 Russian, 1 Western.  
[161=5303]

## RADIATIVE DISSIPATION OF TEMPERATURE PERTURBATIONS IN EARTH'S UPPER ATMOSPHERE WITH ALLOWANCE FOR DISRUPTION OF LOCAL THERMODYNAMIC EQUILIBRIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 9 Dec 81, after revision 8 Jun 82)  
pp 476-482

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[Abstract] The authors give numerical estimates of the radiative dissipation of temperature perturbations in the earth's upper atmosphere when there is a disruption of local thermodynamic equilibrium. Radiation transfer in the CO<sub>2</sub> band 15  $\mu$ m is examined. Two mutually supplementary models are used (both are examined in detail): a model of radiative dissipation of a temperature perturbation in the form of a plane harmonic wave in an infinite medium and a model of dissipation involving cooling into universal space. It is shown that

among the two models it is necessary to select that which gives the maximum dissipation value for specific conditions. The estimates are obtained in the approximation of the Doppler line contour by the universal functions method for integral absorption in the vibrational-rotational bands and are applicable to the layer of the earth's atmosphere above 70 km. For wave movements in the upper mesosphere and lower thermosphere it is evidently possible to expect a noticeable effect of radiative dissipation only on the propagation of the diurnal tide. Figures 2; references 15: 10 Russian, 5 Western.  
[161-5303]

UDC 551.593.7

#### POLARIZATION CONTRAST

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 3 Mar 82) pp 483-489

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[Abstract] Observable contrast is created by the brightness difference of adjacent light fields sensed by an optical detector. The light entering into the detector from the observed objects, like from the masking aerosol haze, is differently polarized. The state of its polarization is determined by the characteristic properties of the objects and atmosphere and the conditions for their illumination. The optical detector is characterized not only by its response, but also its susceptibility to light polarization. The observed contrast is dependent on the difference in the properties of the observed objects, their distances from the observer, properties of the aerosol haze, conditions for illumination of the objects and haze, as well as the parameters (including tuning) of the detector. There is a thorough discussion of the problem of visibility in the atmosphere of objects illuminated by polarized light, including the change in the polarization state of the light ray during its passage from the observed object to the detector as a function of conditions of illumination of the background, sky luminosity, solar zenith angle and optical properties of the aerosol haze. On the assumption that the polarization response of the detector is known it was possible to clarify the conditions for attaining maximum image contrast. A number of specific situations are examined in detail. The article is organized in 9 sections: 1) Polarization contrast of light fields; 2) Polarization contrast of near-lying objects; 3) Polarization contrast of distant objects; 4) Observability range; 5) Monitoring contrast; 6) Scintillation contrast; 7) Spectral contrast; 8) Functional contrast; 9) Contribution of haze. References: 5 Russian.  
[161-5303]

## SHORTENED DESCRIPTION OF CLOUDLESS SKY BRIGHTNESS SPECTRA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 5, May 83 (manuscript received 9 Nov 81) pp 490-496

STAVITSKAYA, N. A. and YAKOVLEV, A. A.

[Abstract] An investigation of the spectral and spatial distribution of brightness of the cloudless sky is important for many practical problems in atmospheric physics. In order to simplify description of the variability of spectral brightness of different parts of the sky it is desirable to select a small number of narrow spectral intervals in which there is assurance of a quite good approximation of the brightness spectrum in a broad spectral range. The article gives an in-depth examination of the problem of best choice of such spectral intervals for describing the spectral brightness of the sky in the visible optical range. A regression model is proposed for brightness of the daytime sky in the visible spectral range, making it possible to relate the sky brightness values in three spectral intervals (440, 560 and 680 nm) and the brightness values in the entire range 400-700 nm. The error in predicting the spectral brightnesses by the proposed model does not exceed the measurement errors. An example is given illustrating the possibility of using the parameters of the model for describing the brightness spectra of the daytime sky in another region of the earth. Figures 2, tables 2; references 7: 3 Russian, 4 Western.  
[161-5303]

DC 551.501.724

## REMOTE DETERMINATION OF ATMOSPHERIC TEMPERATURE BY LIDAR FROM ROTATIONAL SPECTRUM OF COMBINATION SCATTERING

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 4, Apr 83 (manuscript received 6 Jul 81, after revision 4 Mar 82)  
pp 431-434

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[Abstract] The authors give the results of experimental studies of remote determination of atmospheric temperature by means of lidar in the purely rotational spectrum of combination scattering of nitrogen and oxygen. The method is based on the temperature dependence of the ratio of intensities of two sectors of this purely rotational spectrum (Yu. F. Arzhinov, et al., ZH. PRIKL. SPEKTROSKOPII, Vol 32, No 4, 1980). A block diagram in the text shows the sounding path, along which there is a distributed sensor of a resistance thermometer which makes it possible to measure temperature averaged for a volume with a length of about 60 m. The horizontal sounding path runs



parallel to the distributed sensor at a distance of about 5 m. The lidar includes a Cu laser with an unstable resonator; the mean power at 510 nm is 5 W, the repetition rate is 6-7 KHz and beam divergence is  $4.5 \cdot 10^{-4}$ . The receiver is a two-lens objective with a diameter of 0.3 m and a focal length of 0.9 m. The laser radiation is directed into the atmosphere strictly along the optical axis of the objective. The radiation scattered by the atmosphere is directed from the objective to the entrance slit of a double monochromator which is used in separating the two parts of the rotational spectrum of combination scattering of  $N_2$  and  $O_2$  and for suppressing the background. Two photomultipliers are used in registering these observations. A computer is used in processing the results at a real time scale. The readings of a digital thermometer are fed to the computer simultaneously with lidar data. The temporal variation of atmospheric temperature is monitored using data from the lidar and contact measurements. The results are given in a series of figures. The data obtained by the two methods are in good agreement. The results confirm the effectiveness of the lidar method and it is hoped that in the near future such measurements can be used in obtaining profiles of atmospheric temperature to altitudes of about 1 km. Figures 4; references 11: 6 Russian, 5 Western. [139-5303]

UDC 535.36:551.593.7:551.535.51

# MATRIX COEFFICIENT OF RADIATION BRIGHTNESS REFLECTED BY SEMI-INFINITE ABSORBING MEDIUM WITH HIGHLY ANISOTROPIC SCATTERING FUNCTION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 19, No 4, Apr 83 (manuscript received 14 Dec 81, after revision 20 Apr 82) pp 390-399

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[Abstract] Solution of problems in such fields as hydrooptics, cloud optics and astrophysics requires a knowledge of the polarization characteristics of radiation reflected by a semi-infinite scattering medium. The properties of the medium are described by the matrix brightness coefficient  $\hat{P}$  determined as:

$$S(\mu, \varphi) = \mu_0 \hat{P}(\mu, \mu_0, \varphi - \varphi_0) S_0(\mu_0, \varphi_0),$$

where  $S$  and  $S_0$  are the Stokes parameters for radiation reflected in the direction  $n(\theta, \varphi)$  and incident in the direction  $[-n_0(\theta_0, \varphi_0)]$ ,  $\mu = \cos \theta$ ,  $\mu_0 = \cos \theta_0$ ,  $\theta$ ,  $\theta_0$  are the polar and  $\varphi$ ,  $\varphi_0$  are the azimuthal angles in a spherical coordinate system with the  $z$ -axis along the normal to the surface of the medium. The authors here solve the problem of determining the elements of the matrix  $\hat{P}(\mu, \mu_0, \varphi - \varphi_0)$  for a case when the scattering function is strongly elongated forward and appreciable true absorption is present in the medium. These conditions are observable in clouds in the IR spectral region and in sea water. Approximate formulas are derived for the matrix coefficient of radiation brightness. Their relationship to the single-scattering matrix is analyzed and the accuracy of the formulas is evaluated. It is planned that specific computations of the reflection matrices for some geophysical media and a quantitative evaluation of the considered effects be published in the near future. Figures 1; references 8: 6 Russian, 2 Western. [139-5303]

# MODEL COMPUTATIONS OF TURBULENT DIFFUSION COEFFICIENTS FOR NONSTRATIFIED ATMOSPHERIC SURFACE LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 4, Apr 83 (manuscript received 3 Jun 82) pp 366-375

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[Abstract] During recent years "second-order closures" have been repeatedly applied to currents in the atmosphere, but the very simple problem of diffusion of a neutral (unheated, nonprecipitating and chemically passive) impurity in a horizontally homogeneous and stationary neutrally stratified atmospheric air layer has never yet been examined within the framework of any existing "second-order closures." The author has examined variants of "second-order closure" consistent with the more elementary K theory but making possible a theoretical evaluation of the coefficients of turbulent diffusion, concerning which little is known. All the components of the tensor of the coefficients of turbulent diffusion of a neutral impurity in a logarithmic sublayer are evaluated. Then the values of these coefficients are used in determining the principal characteristics of scattering of a cloud of impurity from a surface instantaneous point source. References 27: 8 Russian, 19 Western.  
[139-5303]

UDC 551.558.21:551.511.3

# SPATIAL PROBLEM OF FLOW OF INCOMPRESSIBLE STRATIFIED FLUID AROUND OBSTACLE (NUMERICAL MODELING)

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 19, No 4, Apr 83 (manuscript received 7 Jan 82, after revision 14 Apr 82)  
pp 357-365

GRANBERG, I. G., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] A method has been developed making it possible to carry out numerical integration of three-dimensional nonlinear equations in the problem of a flow of stratified fluid around an obstacle of a stipulated configuration. The problem is solved using a system of equations written in  $(x, y, \rho)$  coordinates. A stationary solution is found, with the entire procedure for obtaining a numerical solution being outlined. The model used here has a number of distinctive features: 1) the obstacle has an arbitrary configuration, 2) the free surface condition at top, 3) a procedure for solving the problem for an incompressible fluid without solution of an elliptical equation, 4) a small number of computation points. Two specific examples are cited. Encouraging results are demonstrated. The simple method appears to be effective not only for any configurations of obstacles, but also for any

profiles of velocity and stratification of the oncoming flow. In the stationary problem the solution is obtained as a limiting regime when  $t \rightarrow \infty$ . Over the obstacle there are vertically propagating waves transporting energy downflow and there is a horseshoe-shaped region around the obstacle, with "capture" regions being situated downflow. Figures 4; references 14: 5 Russian, 9 Western.  
[139-5303]

UDC 550.388.2

INFLUENCE OF PERTURBATIONS IN LOWER IONOSPHERE PARAMETERS BY POWERFUL RADIO WAVES ON PARTIALLY REFLECTED SIGNALS

Kiev GEOFIZICHESKIY ZHURNAL in Russian Vol 5, No 4, Jul-Aug 83  
(manuscript received 12 Jul 80) pp 90-96

MARTYNENKO, S. I. and CHERNOGOR, L. F., Khar'kov State University

[Abstract] A study is made of the interaction of a powerful short-wave radiation pulse with the ionospheric plasma in the D area and the influence of the artificial disturbances thus formed on the characteristics of partially reflected radio signals used in partial reflection installations. The results of calculations of the influence of nonlinear effects obtained within the framework of the classical theory of partial Fresnel reflection can be applied to the case of volumetric scattering of probing signals. The calculations show that existing partial reflection installations can significantly disturb the parameters of the lower ionosphere, which means that installations with effective powers of not over about 10 MW at 2 MHz and 15 to 20 MW at 6 MHz should be used. Exceeding these values of PG will result in significant errors due to the appearance of nonlinear effects. Figures 11; references 7 (Russian).  
[202-6508]

CSO: 1865

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